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SCIENTIFIC CULTURE:

ITS SPIRIT, ITS AIM, AND ITS METHODS.*

By JOSIAH PARSONS COOKE.

I ASSUME that most of those whom I address are teachers, and that you have been drawn here by a desire to be instructed in the best methods of teaching physical science. It has therefore seemed to me that I might render a real service, in this introductory address, by giving the results of my own experience and reflection on this subject; and my thoughts have been recently especially directed to this topic by the discussion in regard to the requisites for admission, which during the past year have actively engaged the attention of the faculty of this college.

At the very outset of this discussion we must be careful to make a clear distinction between instruction and education—between the acquisition of knowledge and the cultivation of the faculties of the mind. Our knowledge should be as broad as possible, but, in the short space of human life, it is not, as a rule, practicable to cultivate, for effective usefulness, the intellectual powers in more than one direction.

Let me illustrate what I mean from that department of knowledge which is at once the most fundamental and the most essential. I refer to the study of language. No person can be regarded as thoroughly educated who has not the power of speaking and writing his mother-tongue accurately, elegantly, and forcibly; and scholars of the present day must also command, to a considerable extent, both the French

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and the German languages. These three languages, at least, are the necessary tools of the American scholar, whatever may be the special field of his scholarship, and his end is gained if he has acquired thorough command of these tools. But if he goes further, and studies the philology of these languages, their structure, their derivation, their literature, the study may occupy a lifetime, and be made the basis of severe intellectual training. More frequently, and as most scholars think more effectually, such linguistic training is obtained by the study of the ancient languages, especially the Latin and the Greek, and no one questions the value and efficiency of this form of mental discipline. But obviously such a preparation is not necessary for the use of the modern languages as tools, or in order to acquire a knowledge of ancient history, of the modes of ancient life, or the results of ancient thought. In recent discussions a great deal has been said about the value of classical learning, and it has been argued that no man could be regarded as thoroughly educated who had never heard of Homer or Virgil, of Marathon or Cannæ, of the Acropolis of Athens or the Forum of Rome. Certainly not. But all this knowledge can be acquired without spending six years in learning to read the Latin and Greek authors in the original, or in writing Latin hexameters or Greek iambics. The discipline acquired by this long study is undoubtedly of the highest value, but its value depends upon the intellectual training, which is the essential result, and not upon the knowledge of ancient life and thought, which is merely an incident.

Now, this same distinction, which I have endeavored to illustrate on familiar ground, must not be forgotten in considering the relations of physical science to education. Physical science may also be studied from two wholly different points of view: First, to acquire a knowledge of facts and principles, which are among the most important factors of modern life; secondly, as a means of developing and training some of the most important intellectual faculties of the mind—for example, the powers of observation, of conception, and of inductive reasoning.

The experimental sciences must often be studied chiefly from the first point of view. If no man can be regarded as thoroughly educated who is ignorant of the outlines of Roman and Greek history; one who knows nothing of the principles of the steam-engine, or of the electric telegraph, is certainly equally deficient. I do not question that in most of our high-schools the physical sciences must be taught, for the most part, as funds of useful knowledge, and in regard to such teaching I have only a few remarks to make. Assuming that information is the end to be attained, the best method of securing the desired result is to present the facts in such a way as will interest the scholar, and thus secure the retention of these facts by his memory. I think it a very serious mistake to attempt to teach such subjects by *memoriter* recitations from a text-

book, however well prepared. This method at once makes the subject a task; and, if in addition the preparation for an examination is the great end in view, it is wonderful how small is the residuum after the work is done. Such subjects can always be made intensely interesting if presented by lectures, with the requisite illustrations, and I do not believe that the cramming process required to pass an examination adds much to the knowledge previously gained. Many teachers, finding that the parrot-like learning of a text-book is unprofitable, attempt to make the exercise more valuable by means of problems—usually simple arithmetical problems—depending upon principles of physics or chemistry. And there can be no doubt that such problems do serve to enforce the principles they illustrate; but I am afraid they also more frequently, by disgusting the student, stand in the way of the acquisition of the desired knowledge.

It must not be forgotten, in studying the results of science, that the facts are never fully learned unless the learner is made to understand the evidence on which the facts rest. The child who reads in his physical geography that the world revolves on its axis, learns what to him is a mere form of words, until he connects this astronomical fact with his own observation that the sun rises in the east and sets in the west; and so the scholar who reads that water is composed of oxygen and hydrogen has acquired no real knowledge until he has seen the evidence on which this fundamental conclusion rests. Let, then, the sciences be taught as they have been in schools, as important parts of useful knowledge, but let them so be taught as to engage the interest of the scholar, and to direct his attention to the phenomena of Nature.

All this, however, is not scientific culture, in the sense in which I have constantly used the term, and does not afford any special training for the intellectual faculties. For myself, I do not desire any study of natural history, chemistry, or physics from this point of view as a preparation for college; simply because, with the large apparatus of the university, all these subjects can be presented more effectively, and be made more interesting, than is possible in the schools. What I desire to see accomplished by our schools is a training in physical science, comparable in extent and efficiency with that which they now accomplish in the ancient languages. And this brings me to another topic, namely, scientific culture as a system of mental training.

Before attempting to state in what scientific culture consists, we shall do well, even at the expense of some repetition, to show that what often passes for scientific culture is far different from the system of education which we have so constantly advocated. The acquisition of scientific knowledge, however extensive, does not in itself constitute scientific culture, nor is the power of reproducing such knowledge, at a competitive examination, any test of real scientific power. Nevertheless, the examination papers which have been pub-

lished by the universities of England and of this country show that this is the sole test of scientific scholarship on which most of these universities rely, in awarding their highest honors to students in physical science. The power of so mastering a subject as to be able to reproduce any portion of it with accuracy, completeness, and elegance, at a written examination, is the normal result of literary, not of scientific, culture, and the power is of the same order, whether the subject-matter be philology, literature, art, or science. Indeed, scientific are, as a rule, much less adapted than literary subjects to the cultivation of this power. Moreover, it is also true that scholars, having attained to a very high degree of scholarship, may not possess this power of stating clearly and concisely the knowledge they actually possess. We have all of us known eminent men, possessing in a very high degree the power of investigating Nature, who have been wholly unable to state clearly the knowledge they have themselves discovered. Great harm has been done to the cause of scientific culture by attempting to adapt the well-tried methods of literary scholarship to scientific subjects: for, as I have said in another place, competitive examinations are no test of real attainment in physical science.

Let me not be understood as disparaging the retentive memory and power of concentration which enable the student to reproduce acquired information with accuracy, rapidity, and elegance. This is a power of the very highest order, and is the result of the cultivation to a high degree of many of the noblest faculties of the mind. All I wish to enforce is, that success in such examinations is no indication of scientific culture, properly so called.

What, then, are the tests of true scientific scholarship? The answer can be made perfectly plain and intelligible. The real test is the power to study and interpret natural phenomena. As in classical scholarship the true test of attainment is the power to interpret the delicate shades of meaning expressed by the classical authors, so in science the true test is the power to read and interpret Nature; and this last power, like the other, can as a rule only be acquired by careful and systematic training. As some men have a remarkable facility for acquiring languages, so also there are men who seem to be born investigators of Nature; but by most men such powers can only be acquired through a careful training and exercise of the faculties of the mind, on which success depends. No man would be regarded as a classical scholar, however broad and extended his knowledge, if that knowledge had been acquired solely by reading English translations of the classical authors, however excellent. So, no man can be regarded as a scientific scholar whose knowledge of Nature has been solely derived from books. In either case the real scholar must have been to the fountain-head and drawn his knowledge from the original sources. In order, then, to discover how scientific culture must be gained, we

must consider the conditions on which the successful study and interpretation of Nature depend.

Of the powers of the mind called into exercise in the investigation of Nature, the most obvious and fundamental is the power of observation. By power of observation is not meant simply the ability to see, to hear, to taste, or to smell with delicacy, but the power of so concentrating the attention on what we observe as to form a definite and lasting impression on the mind. There are undoubtedly great differences among men in the acuteness of their sensations, but successful observation depends far less upon the acuteness of the senses than on the faculty of the mind which clearly distinguishes and remembers what is seen and heard. We say of a man that he walks through the world with his eyes shut, meaning that, although the objects around him produce their normal impression on the retina of his eye, he pays no attention to what he sees. The power of the naturalist to distinguish slight differences of form or feature in natural objects is simply the result of a habit, acquired through long experience, of paying attention to what he sees, and the want of this power in students who have been trained solely by literary studies is most marked.

An assistant who was at the time conducting a class in mineralogy, once said to me: "What am I to do? One of my class can not see the difference between this piece of blend and this piece of quartz" (showing me two specimens which bore a certain superficial resemblance in color and general aspect). My answer was, "Let him look until he can see the difference." And, after a while, he did see the difference. The difficulty was not lack of vision, but want of attention.

The power of observation, then, is simply the power of fixing the attention upon our sensations, and this power of fixing the attention is the one essential condition of scholarship in all departments of learning. It is a power which ought to be cultivated at an early age, and in a system of scientific culture the sciences of mineralogy and botany afford the best field for its culture, and I should therefore place them among the earliest studies of a scientific course. Minerals and plants may be profitably studied in the youngest classes of our secondary schools, but they should be studied solely from specimens, which the scholar should examine until he can distinguish all the characteristics of form, feature, or structure. I am told that in many of our secondary schools both mineralogy and botany are studied with great success and interest in the manner I have indicated. But a mistake is frequently made in attempting to do too much. With mineralogy or botany as classificatory sciences, our secondary schools should have nothing to do. The distinction between many, even of the commonest, species of minerals or plants depends upon delicate distinctions which are quite beyond the grasp of young minds, and the study of botany frequently loses all its value, through the ambition of the teacher

to embrace so much of systematic botany as will enable scholars "to analyze plants."

If a child, twelve or fourteen years of age, is made to observe the characteristic qualities of a few common minerals so as to enable it to recognize them in the rocks, and is likewise led to examine the structure of a few familiar flowers, not only will a new power have been acquired, but a new interest will have been added to life.

Of course, the faculty of observation thus early exercised in childhood only attains the highest degree of development after long experience and continued practice. The acuteness which practice gives is frequently very remarkable, and rude men often surprise us by the extent to which their power of observation has been cultivated in certain special directions. The sailor who recognizes the outlines of to him a well-known coast, where the ordinary traveler sees nothing but a bank of clouds, or the miner who recognizes in the rock indications of valuable ores, are illustrations which may give a clearer conception of the nature of the power we have been attempting to describe.

Naturally following the power of observation in the order of education is the power of conception with the cognate power of abstraction; that is, the power of forming in the mind distinct and accurate images of objects, and relations, which have been previously apprehended either by direct observation, or through description; and also the power of confining the attention to certain features which these images may present to the exclusion of all others. This is a power which depends very greatly on the imagination and is capable of being cultivated to a very high degree. There is no study which is so well suited to the training both of the powers of conception and of abstraction as the study of geometry.

To this end the study of geometry should be begun at an early period in school-life, and it should be studied at first not as a series of propositions logically connected, but as a description of the properties and relations of lines, surfaces, and solids—what has sometimes been called "the science of form." A text-book prepared on this idea by Mr. G. A. Hill forms an admirable introduction to the study.

I esteem very highly the system of geometry of Euclid, either in its original form or as it has been modified by modern writers, as a means of developing the logical faculty. The completeness of the proof of the successive propositions and their mutual dependence by means of which, as on a series of steps, we mount from simple axiomatic truths to the most complex relations, furnish an admirable discipline for the reasoning power; but too often the whole value of this discipline is lost by the failure of the pupil to form a clear conception of the very relations about which he is reasoning, and the study becomes an exercise of the memory and nothing more. Often have I seen a conscientious and faithful student draw an excellent figure, and write out an accurate demonstration, without noticing that the two were not

mated; and in a recent meeting of teachers of our best secondary schools it was gravely asserted that solid geometry was the most difficult study with which the teachers had to deal. In solid geometry, however, the reasoning is no more difficult than in plane geometry, but the conceptions are far more complex, and, if the teacher insisted that the pupil should not take a single step until his conceptions were perfectly clear, all the difficulties would disappear. Of this I am fully persuaded, for I have had to encounter the same difficulties over and over again in teaching crystallography. In beginning the study of geometry, of course the power of conception should be helped in every possible way. Let your pupil find out by actual measurement that the sum of the angles of a triangle is equal to two right angles, and he will easily discover the proof of the proposition himself. So also, if he actually divides with his knife a triangular prism made from a potato or an apple into three triangular pyramids, he will find no difficulty in following the reasoning on which the measurement of the solid contents of a sphere depends. Let me assure teachers that the study of geometry, taught as I have indicated, is a most valuable introduction to the study of science. But, as it has been usually taught as a preparation for college, it is almost worthless in this respect, however valuable it may be as a logical training.

I consider practice in free-hand drawing from natural objects a most valuable means of training both the power of observation and the power of conception, besides giving a skill in delineation which is of the greatest importance to the scientific student. Accuracy of drawing requires accuracy in observation, and also the ability to seize upon those features of the object which are the most prominent and characteristic. Hence, in a course of scientific training, the importance of practice in drawing can hardly be exaggerated, and it should be made one of the most important objects of school-work from an early period.

To the scientific student the powers of observation and conception are not sought as ends in themselves, but as means of studying Nature. The precise portions of this wide field to which the attention of the student shall be directed will be determined by many circumstances, and it is not our purpose in this address to lay down a plan of study. To most students the natural history subjects offer the most attractive field; but all, I think will admit, that the experimental sciences should form a considerable portion, at least, of the course of all scientific students, whatever specialty may subsequently be chosen. That on which I desire particularly to dwell is the spirit in which all these studies should be pursued; and I can best illustrate what I mean by confining my remarks to that subject in which I am most interested, and in regard to which I have the greatest experience.

In a course of scientific study, chemistry can not be dissociated from physics, and the two sciences ought to be studied to a great extent in

connection with each other. Not only does the philosophy of chemistry rest upon physical conceptions; but, moreover, chemical methods involve physical principles. There is, however, a distinction to be made; for, while some of the departments of physics are best studied as a preparation for chemistry, there are other subjects which are best deferred until the student has some knowledge of chemical facts. Among the preliminary subjects we should mention elementary mechanics, including hydrostatics and pneumatics, and also thermotics; while electricity, acoustics, and optics, including the large subject of radiant energy, may well be deferred until after the study of chemistry.

In the study both of chemistry and physics there are of course two definite objects to be kept in view: In the first place, a knowledge of the facts of the science is to be acquired; in the second place, the student must learn by experience how these facts have been discovered. It would be obvious, from a moment's reflection, that a knowledge of the circumstances under which the facts of Nature are revealed to the student is essential to a complete apprehension of the facts themselves. The child who is taught that the earth moves in an elliptical orbit around the sun in one year does not in the least grasp the wonderful fact thus stated, and will not come to realize it until he connects the statement with the nightly precession of the stars in the heavens. And it is just such a connection as this which the teacher must seek to establish in all scientific teaching. In experimental science such a connection is most readily established in the mind of the student by means of a series of well-arranged experiments, which each one repeats for himself at the laboratory table. Obviously, however, it is impossible, in a limited course of teaching, to go over the whole ground of chemistry or physics in this way, or even over that small portion of the ground with which the average scientific student can expect to become acquainted. Nor is this necessary; for, after one has realized the connection between phenomena and conclusion in a number of instances, the mind will fully comprehend that a similar connection exists in other cases, and will understand the limitations with which scientific conclusions are to be received.

Hence, it seems to me that, in teaching chemistry or physics, it is best to combine a course of lectures which should give a broad view of the whole ground with a course of laboratory instruction, which must necessarily be more or less restricted. Experimental lectures are, I am convinced, much the best way of presenting these subjects as systematic portions of knowledge. It is not necessary that the lectures should be formal, but it is all-important that they should be given in such a way that the interest of the student should be awakened, and that they should be fully illustrated by specimens and experiments. What we read in a book does not make one half the impression that is produced by the words of a living teacher, nor can we realize the facts unless we see the phenomena described. There is undoubtedly,

however, an advantage to be gained in subsequently reviewing the subject as presented in a good text-book, and such a book may be of great use in preparation for an examination. But how far examinations are of value in enforcing the acquisition of knowledge of an experimental science is a question on which I feel a grave doubt. Certainly their value is very small if, as is too frequently the case, they lead the student to defer all effort to make his own the knowledge presented in the lectures, until a final cram.

The management of lectures, text-books, and examinations, will not, however, offer nearly so great difficulties to the teacher as the management of the parallel experimental course of laboratory teaching. In the last the methods are less well tried and demand of the teacher a very considerable amount of invention and experimental skill. To follow mechanically any text-book would result in a loss of the proper spirit with which the course should be conducted and which constitutes its chief value. No experiments are so good as those which have been devised by the teacher, or, still better, by the pupils themselves. A mere repetition of a process, according to a definite description, has no more value than a repetition of a form of words in an ordinary school recitation. The teacher must make sure that the student fully understands what he is about, and comprehends all the connections between observations and conclusions which it is his aim to establish. Moreover, he must constantly encourage his students to think and work for themselves, and direct them in the methods of inductive reasoning. The failure of an experiment may be made most instructive if the student is led to discover the cause of the failure. A leak in his apparatus may be turned to a similar profit if the student is shown how to discover the leak, by carefully eliminating one part after another until the weak point is made evident.

The direction of an experimental laboratory is no easy task. The teacher must make each man's work his own, and follow his processes of thought as well as his experiments with the most careful attention. With large classes much time can be saved by going through each process on the lecture-room table and giving the directions to the class as a whole ; but this does not supersede the personal attention and instruction which each student requires at the laboratory table. Moreover, in laboratory teaching the teacher must rely, as we have said, on his own resources, and but few aids can be given. There are books, however, which will help the teacher to prepare himself for his work, and I am happy to say that a book entitled "The New Physics," prepared by my colleague, Professor Trowbridge, is now being printed, which I hope will greatly promote the laboratory teaching of physics. Nicholl's abridgment of Eliot and Storer's "Manual" has long served a similar valuable purpose in chemistry, and there are many excellent works on "Qualitative Analysis," a study which is admirably adapted to develop the power of inductive reasoning.

There is, however, a danger with all laboratory manuals, which must be sedulously avoided, and the danger is generally greater the more precise the descriptions. They are apt to induce mechanical habits which are fatal to the true spirit of laboratory teaching. Not long ago I asked a student, who was working in our elementary laboratory, what he was doing. He answered that he was doing No. 24, and immediately went for his book to see what No. 24 was. I fear that a great deal of laboratory work is done in a way which this anecdote illustrates, and, if so, it is a mere waste of time.

When teaching qualitative analysis it was always with me a constant struggle to prevent just such a result, and many of the excellent tables which have been prepared to facilitate analysis simply encourage the evil practice. It is an error to which college students, with their exclusively literary preparation, are especially liable, and I have no question that the proper conduct of our laboratories would be made much easier if the students came with a previous scientific training.

Thus far I have dealt solely with generalities, and my object has been not so much to give definite directions as to make suggestions which might lead to better systems of teaching. The details of these systems may vary widely, and yet all may lead to the desired result if only the true spirit of scientific teaching is preserved, and a teacher's own system is generally the best system for him. This leads me to explain my own system of teaching chemistry—which presents some novelties that may be of interest, and, although it has been worked out in detail in the revised edition of the "New Chemistry," just published, still a few words of explanation may be of value at this time in setting forth its salient points.

Chemistry has been usually defined as the science which treats of the composition of bodies, and in most text-books the aim has been to develop the scheme of the chemical elements, and to show that, by combining these elements, all natural and artificial substances may be prepared. In the larger text-books, which aim to cover the whole ground and to describe all known substances, such a method is both natural and necessary. But, as an educational system, this mode of presenting the subject is, as a rule, profitless and uninteresting. The student becomes lost amid details which he can only very imperfectly grasp, and the great principles of the science, as well as their relations to cognate departments of knowledge, are lost sight of. Moreover, the system is unphilosophical, because it presents the conclusions of chemistry before the observations on which they are based. Any one who has attempted to teach chemistry from the ordinary elementary text-books must have experienced the truth of what I have said.

A student learns a lesson about sodium and the various salts of this metal, and, after glibly reciting the words of the text-book, how much more does he know of the real relations of these bodies than he did

before? Thus. Chloride of sodium symbol, NaCl. Crystallizes in cubes. Soluble in water. Solubility only slightly increased by heat. Generally obtained by evaporation of sea-water in pans. Also found in beds in certain geological basins from which it is extracted by mining. When acted upon by sulphuric acid, hydrochloric acid is evolved and sodic sulphate is formed, according to the following reaction, and so on. I have known a student to recite all this and a great deal more, without ever dreaming that he had been eating chloride of sodium on his food, three times a day at least, since he was born.

Now, the rational system of teaching chemistry is first to present to the scholar's mind the phenomena of Nature with which the science deals. Lead him to observe these phenomena for himself; then show him how the conclusions which together constitute that system of knowledge we call chemistry have been deduced from these fundamental facts. My plan is to develop this system in the lecture-room in as much detail as the time allotted will permit; to illustrate all the points by experiment, and in addition to explain more in detail carefully selected fundamental experiments, which the student subsequently repeats in the laboratory himself. Thus I make the lecture-room instruction and the laboratory demonstration go hand in hand as complementary parts of a single course of teaching.

To begin with the subject-matter of chemistry. In the broad fields of Nature what portion does this science cover? Natural phenomena may obviously be divided into two great classes: First, those changes which do not involve a transformation of substance; and, secondly, those changes whose very essence consists in the change of one or more substances into other substances having distinctive properties. The science of physics deals with the phenomena of the first class; the science of chemistry with those of the last. Any phenomenon of Nature which involves a change of substance is a chemical change, and in every chemical change one or more substances, called the factors, are converted into another substance or into other substances called the products. The first point to be made in teaching chemistry is, that a student should realize this statement, and a number of experiments should be shown in the lecture-room and repeated in the laboratory illustrating what is meant by a chemical change.

Here, of course, arises a difficulty in finding examples which shall be at once simple and conclusive, for in almost all natural phenomena there is a certain indefiniteness which obscures the simple process. The familiar phenomena of combustion are most striking examples of this fact, and men were not able to penetrate the mist which obscured them until within a hundred years. To find chemical processes whose course is obvious to an unpracticed observer, we are obliged to resort to unfamiliar phenomena.

A very simple example of a chemical process is a mixture of sulphur and zinc in atomic proportions, which, when lighted with a

match, is rapidly converted into white sulphide of zinc, with appearance of flame. Another example, a mixture of sulphur and fine iron-filings, which, when moistened with a little water, rapidly changes into a black sulphide of iron. Then some copper filings, which, when heated on a saucer in the open air, slowly change into black oxide of copper. Then a bit of phosphorus, burned in dry air under a glass bell, yielding a white oxide. Next, some zinc, dissolved in diluted sulphuric acid, yielding hydrogen gas and sulphate of zinc. Then, a solution of chloride of barium added to a solution of sulphate of soda, giving a precipitate of sulphate of baryta, and leaving in solution common salt, which can be recovered by evaporating the filtrate.

In all these examples the student should be made to see and handle all the factors and all the products of each process, and the experiments should be selected so that he may become familiar with the different conditions under which substances appear, and with various kinds of chemical processes. He should also be made clearly to distinguish between the essential features of the process and the different accessories, which may be more or less accidental—such, for example, as the water used in determining the combination of iron and sulphur, or the flame which accompanies combustion.

After a clear conception has been gained of a chemical process, with its definite factors and definite products, we are prepared for the next important step. Every chemical process obeys three fundamental laws:

The Law of Conservation of Mass.
The Law of Definite Proportions.
The Law of Definite Volumes.

According to the first law, the sum of the weights of the products of a chemical process is always equal to the sum of the weights of the factors. This law must now be illustrated by experiments, and approximate quantitative determinations should be introduced thus early into the course of study. All that is required for this purpose is a common pair of scales, capable of weighing two or three hundred grammes, and turning with a decigramme. We use in our laboratory some platform-scales, made by the Fairbanks Company, which are inexpensive, and serve a very useful purpose.

A very satisfactory illustration of the law of conservation of mass can be obtained by inserting in a glass flask a mixture of copper filings and sulphur in atomic proportions. The glass flask is first balanced in the scale-pan; then removed and gently heated until the ignition which spreads through the mass shows that chemical combination has taken place. The flask is lastly allowed to cool, and on reweighing is found not to have altered in weight.

For a second experiment, a bit of phosphorus may, with the aid of some simple contrivance, be burned inside a tightly corked glass flask, of sufficient volume to afford the requisite supply of oxygen. Of course,

on reweighing the flask, after the chemical change has taken place, and the bottom of the flask covered with the white oxide formed, there will be no change of weight, and this experiment may be made to enforce the truth that, in this example of combustion at least, the chemical process is attended with no loss of material. Open now the flask, and air will rush in to supply the partial vacuum, proving that in the process of combustion a portion of the material of the air has united to form the white product.

Make now a third experiment as an application of the general principle which has been illustrated by the previous experiments. Burn some finely divided iron (iron reduced by hydrogen) on a scale-pan, and show that the process is attended by an increase of weight. What does this mean? Why, that some material has united with the iron to form the new product. Whence has this material come? Obviously from the air, for it could come from nowhere else. And thus, besides illustrating the first of the above laws, this experiment may be made to furnish an instructive lesson in regard to the relations of the oxygen of the atmosphere to chemical processes.

The second law declares that in every chemical process the weights of the several factors and products bear a definite proportion to each other. This law must next be made familiar by experimental illustrations. A weighed amount of oxide of silver is placed in a glass tube connected with a pneumatic trough. The tube is gently heated until the oxide is decomposed and the oxygen gas collected in a glass bottle of sufficient size. The metallic silver remaining in the tube is now reweighed, and the volume of the oxygen gas in the bottle measured, and from the volume of the gas its weight is deduced. The measurement is easily made by simply marking with a gummed label the level at which the water stands in the bottle. If, now, the bottle is removed from the pneumatic trough and the weight of water found which fills the bottle to the same height, the weight of the water in grammes will give the volume of the gas in cubic centimetres, and, knowing the weight of a cubic centimetre of oxygen, we easily calculate the weight of this gas resulting from the chemical process. We have now the weights of the oxide of silver, the silver, and the oxygen, the one factor and the two products of the chemical process, and, by comparing the results of different students making the same experiment, the constancy of the proportion will be made evident to the class.

For a second illustration of the same law, the solution of zinc in dilute sulphuric acid, yielding sulphate of zinc and hydrogen gas, may be selected, and the weight of the hydrogen, estimated as in the previous example, shown to sustain a definite relation to the weight of the zinc dissolved.

Again, silver may be dissolved in nitric acid, and the weight of the nitrate of silver obtained shown to sustain a definite relation to the weight of the metal.

Or, still further, as an experiment of a wholly different class, a known weight of chloride of barium may be dissolved in water, and, after precipitation with sulphuric acid, the baric sulphate collected by filtration and weighed, when the definite relation between the weight of the precipitate and the weight of the chloride of barium will appear.

For a last experiment let the student neutralize a weighed amount of dilute hydrochloric acid with aqua ammonia, noting approximately the amount of ammonia required. Let him now evaporate the solution on a water-bath, and weigh the resulting saline product; taking next the same quantity of hydrochloric acid as before, and, having added twice the previous quantity of ammonia, let him obtain and weigh the resulting sal-ammoniac as before. A third time let him begin with half the quantity of hydrochloric acid, and, adding as much ammonia as in the first case, again repeat the process. It is obvious what the result of these experiments must be, but, without telling the student what he is to expect, it will be a good exercise to ask him to draw his own inferences from the results. Of course, he must previously have so far been made acquainted with the properties of hydrochloric acid and ammonia as to know that the excess of either would escape when the saline solution was evaporated over a water-bath. But with this limited knowledge he will be able to deduce the law of definite proportions from the experimental results thus simply obtained.

The third of the fundamental laws of chemistry stated above (generally known as the law of Gay-Lussac) declares that, when two or more of the factors or products of a chemical process are aëriform, the volumes of these gaseous substances bear to each other a very simple ratio. Here, again, numerous experiments may be contrived to illustrate the law. Water, when decomposed by electricity, yields hydrogen and oxygen gases whose volumes bear to each other the ratio of two to one. When hydrochloric-acid gas is decomposed by sodium amalgam, the volume of the original gas bears to that of the residual hydrogen the ratio also of two to one. When ammonia is decomposed by chlorine, the volume of the resulting nitrogen gas is one third of that of the chlorine gas employed.

Having illustrated these three general laws, attention should be directed to the fact that the nature of a chemical process and the laws which it obeys are results of observation and involve no theory whatsoever. On these facts the science of chemistry is built. The modern system of chemistry, however, assumes what is known as the molecular theory, and by means of this theory attempts to explain all these facts and show their relation to each other. Here the distinction between fact and theory must be insisted upon, and also the value of theory for classifying facts and directing observation.

A molecule is now defined, and, if the student has not studied physics sufficiently to become acquainted with the outlines of the kinetic theory of gases, this theory must be developed sufficiently to give the

student a knowledge of the three great laws of Mariotte, of Charles, and of Avogadro. He must be made to understand how molecules are defined by the physicist, and how their relative weights may be inferred by a comparison of vapor densities. He should then be made to compare the relative molecular weights, deduced by physical means, with the definite proportions he has observed in chemical processes. He will thus himself be led to the conclusion that these definite proportions are the proportions of the molecular weights, and that the constancy of the law arises from the fact that in every chemical process the action takes place between molecules, and that the products of the process are new molecules, preserving always, of course, their definite relative weights. The student will thus be brought to the chemical conception of the molecule as the smallest mass of any substance in which the qualities inhere, and he will come to regard a chemical process as always taking place between molecules.

Thus far nothing has been said about the composition of matter. A chemical process has been defined simply as certain factors yielding certain products, but nothing has been determined about the relations of these several substances except in so far as they are defined by the three laws illustrated above. But now it must be shown that a study of different chemical processes compels us to conclude that in some cases two or more substances unite to form a compound, while in other cases a compound is broken up into simpler parts. Thus, when copper filings are heated in the air, it is evident that the material of the copper has united with that portion of the air we call oxygen to form the black product we call oxide of copper; and again, when oxide of silver is heated, it is evident that the resulting silver and oxygen gas were formerly portions of the material of the oxide. So, when water is decomposed by electricity, the conditions of the experiment show that the resulting oxygen and hydrogen gases must have come from the material of the water, and could have come from nothing else.

Experiments should now be multiplied until the student has a perfectly clear idea of the nature of the evidence on which our knowledge of the composition of bodies depends. The decomposition of chlorate of potash by heat, yielding chloride of potassium and oxygen gas; the decomposition of nitrate of ammonium by heat, yielding nitrous oxide and water; the decomposition of this resulting nitrous oxide, when the gas is passed over heated metallic copper; and, lastly, the decomposition already referred to, of water by electricity, are all striking experiments by which the evidence of chemical composition may be enforced.

The distinction between elementary and compound substances having been clearly defined by the course of reasoning already given in outline, the next aim should be to lead the student to comprehend how substances are analyzed and their composition expressed in percents. The reduction of oxide of copper by hydrogen gives readily the data

for determining the composition of water, which is thus shown to contain in one hundred parts 11·11 per cent of hydrogen and 88·89 per cent of oxygen.

Another substance whose analysis can be very readily made by the student is carbonate of magnesia. By igniting pure carbonate of magnesia in a crucible (not of course the "magnesia alba" of the shops), the proportions of carbonic acid and magnesia can be readily determined. Then, by burning magnesium ribbon, and weighing the product, the student easily finds the relative weight of magnesium and oxygen in the oxide. And, lastly, the proportion of carbon and oxygen in carbonic dioxide is easily deduced from the burning of a weighed amount of carbon. Here the result may be expressed either in percents of oxide of magnesium and carbonic dioxide, or else in percents of the elementary substances, carbon, magnesium, and oxygen.

After making a few analyses like these, the student will be prepared to comprehend the actual position of the science. All known substances have been analyzed, and the results tabulated, so that it is unnecessary to repeat the work except in special cases.

The teacher is now prepared to take a very important step in the development of the subject. If the molecule is simply a small particle of a substance in which the qualities of the substance inhere, then it follows, of course, that the composition of the molecule is the same as the composition of the substance. The percentage results of the analysis of water, or of carbonate of magnesia, indicate the composition of a molecule of water or a molecule of carbonate of magnesia. Thus, 11·11 per cent of every molecule of water consists of hydrogen, while 88·89 per cent consists of oxygen. Hence it follows that, in a chemical process, the molecules must be divided, and these elementary parts of molecules which analysis reveals are the atoms of chemistry. Moreover, as we know the weights of the molecules, both by physical and chemical means, chemical analysis now gives us the weights of the atoms. We have no time to dwell on the details of this reasoning, but the general course to be followed will be evident, and it must be enforced by numerous examples.

Assuming that the student fully comprehends the distinction between molecules and atoms—that is, between the physically smallest particles and the chemically smallest particles—he is prepared to master the symbolical nomenclature of chemistry, with a very few words of explanation. The initial letters of the Latin names are selected to represent the atoms of the seventy known elementary substances, and these letters stand for the definite atomic weights which are tabulated in all chemical text-books. The symbols of the atoms are simply grouped together to form the symbols of the molecules of the various substances; the number of atoms of each kind entering into the composition of the molecule being indicated by a subscript numeral. Lastly, in order to represent chemical processes, the symbols of the

molecules of the factors are written on one side and the symbols of the molecules of the products are written on the other side of an equation, the number of molecules of each substance involved being indicated by numerical coefficients.

The atomic symbols, as we have seen, stand for definite weights. In the same way, the molecular symbols stand for definite weights, which are the sums of the weights of the atoms of which each consists, and in every chemical equation the weights of the molecules represented on one side must necessarily equal the weights of the molecules represented on the other. The chemical process consists merely in the breaking up of certain molecules, and the rearrangement of the same constituent atoms to form new molecules. Again, as the molecular symbols represent definite weights, the equation also indicates that a definite proportion by weight is preserved between the several factors and products of the process represented.

Again, since every molecular symbol represents the same volume when the substance is in an aëriform condition, it follows that the relative gas volumes are proportional to the number of molecules of the aëriform substances involved in the reaction. Thus it is that these chemical equations or reactions are a constant declaration of the three great fundamental laws of chemistry.

In order to enforce the above principles, a great number of examples should now be given which should be so selected as to illustrate familiar and important chemical processes, including the all-important phenomena of combustion. In each case, the student, having made the experiment, should write the equation or reaction which represents the process, and should be made to solve a sufficient number of stochio-metrical problems, involving both weights and volumes, to give him a complete mastery of the subject. Such questions as these will test the completeness of his knowledge:

Why is the symbol of water H_2O? What information does the symbol CO_2 give in regard to carbonic-dioxide gas? Write the reaction of hydrochloric acid on sodic carbonate, and state what information the equation gives in regard to the process which it represents.

Of course, such questions may be greatly multiplied, and I cite these three only to call attention to the features of the method of instruction I have been endeavoring to illustrate.

But, besides teaching the general principles of chemical science, it is important to give the student a more or less extended knowledge of chemical facts and processes—especially such as play an important part in daily life, or in the arts—and such knowledge can readily be given in this connection. Beyond this I do not deem it desirable to go in an elementary course of instruction. The way, however, is now opened to the most advanced fields of the science. A comparison of symbols and reactions leads at once to the doctrine of quantivalence, and to the results of modern structural chemistry, which this doctrine

involves. Among these results there is of course much that is fanciful, but there is also a very large substratum of established truth; and if the student thoroughly comprehends the symbolical language of chemistry, and understands the facts it actually represents, he will be able to realize, so far as is now possible, the truths which underlie the conventional forms.

The study of the structure of molecules naturally leads to the study of their stability, and of the conditions which determine chemical changes, and thus opens the recently explored field of thermochemistry. To be able to predict the order and results of possible conditions of association of materials, or of chemical changes under all circumstances, is now the highest aim of our science, and we have already made very considerable progress toward this end. But I have detained you too long, and I must refer to the "New Chemistry" for a fuller exposition of this subject. My object has been gained if I have been able to make clear to you that it is possible to present the science of chemistry as a systematic body of truths independent of the mass of details with which the science is usually encumbered, and make the study a most valuable means of training the power of inductive reasoning, and thus securing the great end of scientific culture.

THE UPPER MISSOURI RIVER SYSTEM.

By LESTER F. WARD, A. M.

THE Missouri River, as is well known, is the larger of the two great branches which unite to form the Lower Mississippi, discharging at its mouth 120,000 cubic feet of water per second, while the Upper Mississippi discharges only 105,000 cubic feet per second. It is therefore itself properly the Upper Mississippi. The perpetually turbid character of its waters is a familiar fact to the ordinary reader, even if he has never seen them.

It is proposed to state a few facts, derived from a season's personal observation in the valley of the Upper Missouri and of its nearly equal tributary, the Yellowstone, which may account for this condition, and serve to explain the peculiar form of erosion that characterizes this river system.

The upper portion of these rivers, where they flow through mountain-gorges, form deep cañons, and leap over wild cascades, is, of course, more interesting than their lower portions, where the flow, though rapid, is tolerably uniform through valleys of considerable width and among low sand-bars and islands of their own creation. As a consequence of this, we find that it is this upper portion that has received the chief attention by writers and explorers, who hasten through the

duller parts of the country and make only a meager record of them. Another reason for this has been that it is in the region of country about the sources of these rivers that the most profitable mining and agricultural enterprises have been conducted, and large and thriving settlements, even cities, have grown up there, unaided by railroad connections, and communicating with the civilized world by overland routes—not along the river-valley, but across the country from the south, uniting this region with the Salt Lake Basin. It is thus that Helena, Bozeman, Virginia City, and, to a large extent, Fort Benton, now a thriving town, have come into existence, cut off, as it were, on the east, with the great valleys through which the waters of this region are led back to the inhabited parts of the country in a condition akin to unexplored. This was especially the case with the Yellowstone Valley prior to the construction of the Northern Pacific Railroad.

The Yellowstone, from its rapid current of about three miles per hour, its frequent sand-bars, shoals, rapids, and other obstructions, is scarcely navigable at all; while the Upper Missouri, though navigable with great difficulty in high water as far as Fort Benton, or even to its Great Falls, forty miles above that point, possesses a sad history of wrecks, disasters, and failures.

The Yellowstone and Upper Missouri Rivers flow in an easterly direction, nearly parallel to each other and at a distance of about one hundred miles apart, at least for the lower half of their course. Above the Musselshell, which stretches nearly across the intervening space, the country is more or less mountainous, the fall of the water is more rapid, the bottom usually gravelly or rocky, the valleys narrow, and the water clear except in times of flood. Below the Musselshell of the Missouri and the Big Horn of the Yellowstone, nearly opposite, this Mesopotamian region consists of an elevated plain wholly destitude of arborescent vegetation. Its elevation, though not sufficient to be called mountainous, is considerable, and is formed by several distinct rises or terraces. The summit is a level plain, and contains large lakes or marshes in which wild-geese and other water-fowls in immense numbers breed and rear their young. From this plateau long valleys, sometimes of considerable width, descend to the rivers, carrying streams of water which, in some cases, persist throughout the year. The highest part, or divide proper, between the rivers is not central but is nearer the Missouri, which has rugged banks on its south side, with some of the features of the Dakota Bad Lands. Toward the Yellowstone the slope is gradual, and the terraces become lower and lower until the river-valley proper is reached. The right bank of the Yellowstone for most of this distance is similar to the right bank of the Missouri, and toward its mouth the country lying south of the river is not to be distinguished from the true Bad Lands of the Little Missouri adjacent to it. On the other hand, whatever wide flats or

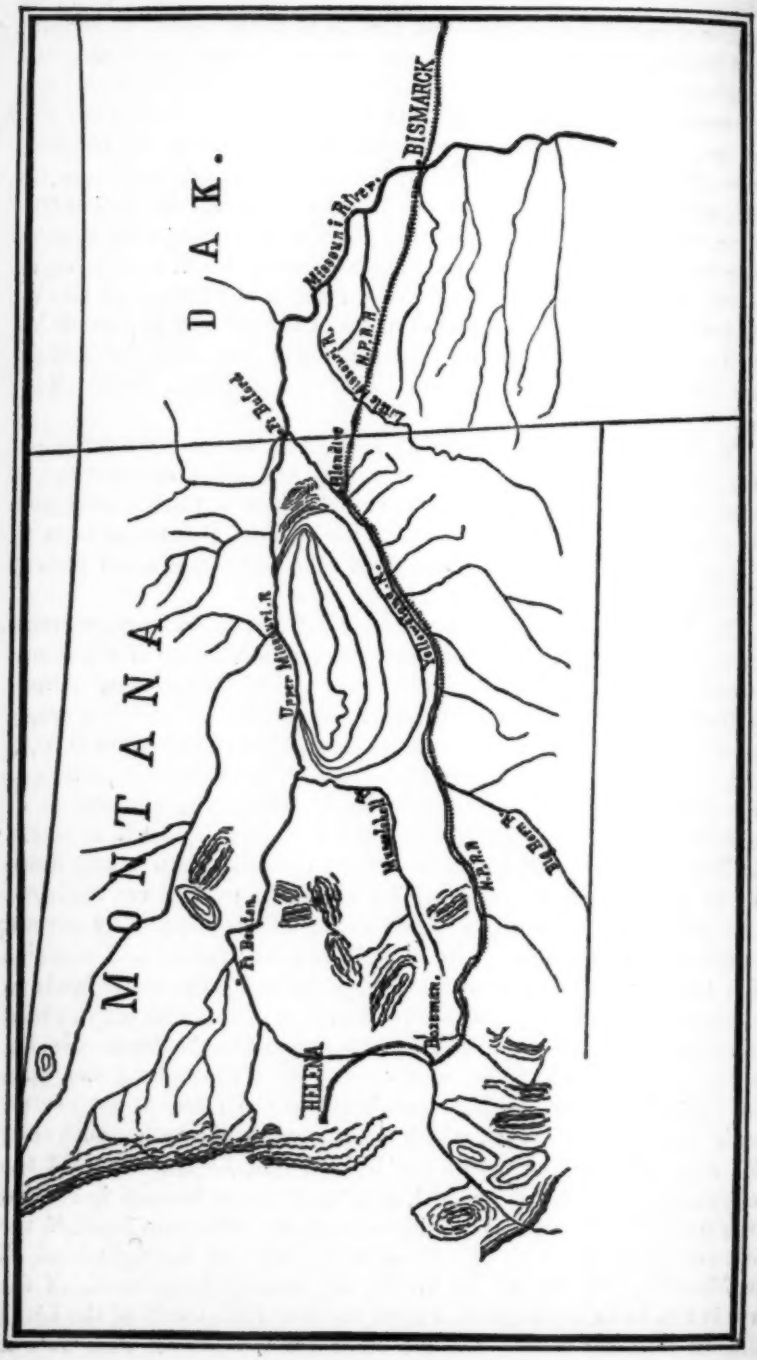

Diagram No. I.—Upper Missouri River System.

low country the Missouri here possesses are generally to be found on the north or left bank of that river (see Diagram No. I).

Without attempting a description of those strange and interesting *mauvaises terres*, which are the favorite theme of popular writers, I shall endeavor to give some idea of the process by which the valleys of these rivers have been formed and of the action of the rivers within their present bed. It is quite evident that the entire configuration of the land-surface of the region has been the result of erosion, and distinct breaks or even low cliffs sometimes occur, showing the edges of the horizontal strata. At intervals of from five to ten miles small streams or creeks fall into the river, often entirely dry in summer, sometimes containing a small quantity of perfectly transparent water, but so charged with alkali as to whiten the pebbles over which it flows, and to render its use by man or beast almost impossible. These creeks, locally denominated *coulées*—a name given them by the early French explorers—have excavated valleys of different lengths and widths, and between these occur narrow plains, or even mere ridges. Of the immense volume of solid earth and rock that has been brought down by the process of eroding these terraces, creek-valleys, etc., only a minute fraction has been retained, but this has been deposited near the river, forming an alluvial bottom of varying width. This alluvial deposit it is the function of the river perpetually to wear away, while at the same time laying down new matter, with which it is constantly charged, to take its place. The result is, that throughout the lower portions of these rivers, and also in the Missouri Valley below their junction, the bed of the river is perpetually shifting its position in the general valley. When we contemplate the entire history of the river, the valley must be regarded as due to this process, and its great width relatively to that of the stream itself can only thus be accounted for. But, if we contemplate it only at a given time, as the present, the valley appears to consist of two quite distinct parts, viz., the river-bed and the valley proper, raised above it and gradually sloping back on one or both sides to the foot of the first terrace. If, in time of low water, we compare these two parts, the latter will appear to be stable, while the former will clearly show that it is unstable. There was probably never a time in the river's history when these two distinct features did not exist much as now, though no one can say how many times the river may have worn away the stable portion of its valley on one side while it was forming anew on the other, and afterward receded and carried off the last-formed valley, leaving its previous bed to be again filled up until it has regained all the aspect of permanence which it previously possessed. This crossing and re-crossing by the river-bed of the general valley, proceeding simultaneously with the work of lateral erosion, have gradually lowered the valley to its present position and are still lowering it. In a certain sense this applies to all rivers and river-valleys, but nowhere perhaps

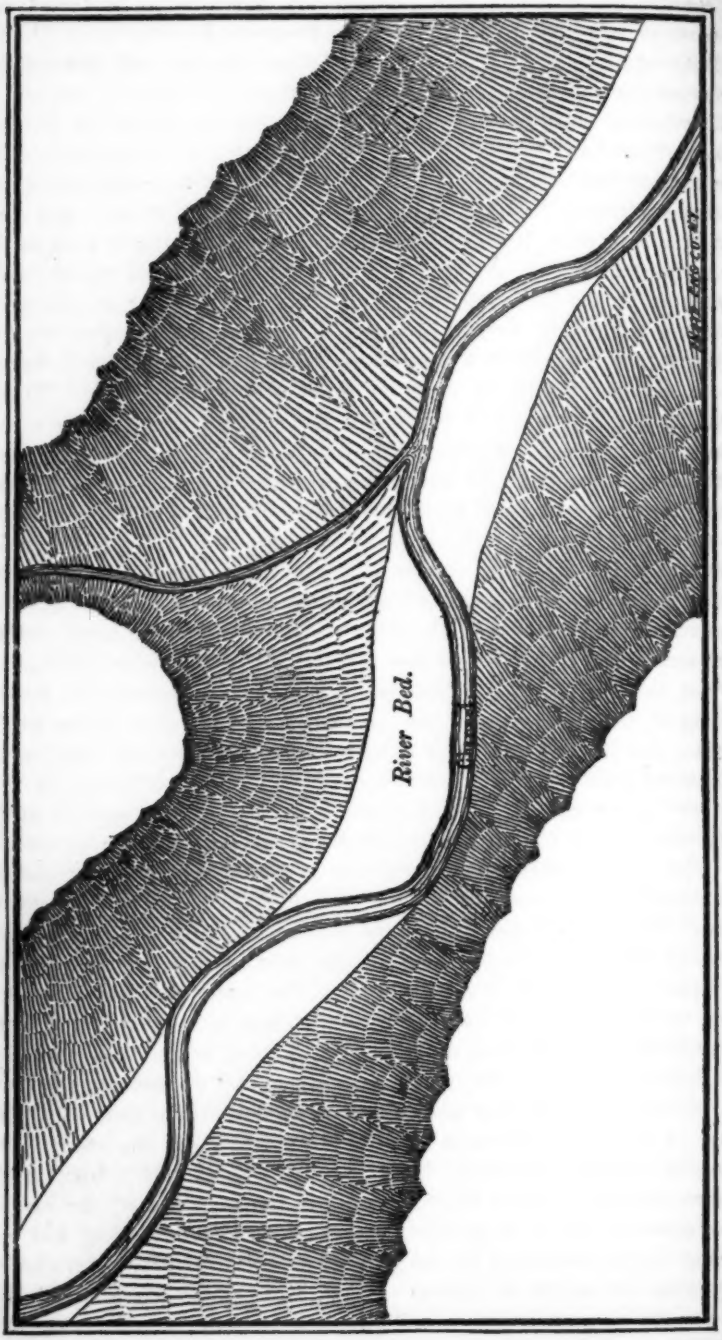

DIAGRAM No. II.—PLAN OF RIVER VALLEY.

on the globe does there exist a better example from which to study these principles of surface erosion than in the Upper Missouri River system. This will be best seen when we consider a little more closely the proper bed of the river.

For two or three months of each year, between March and June, the river is high, and this state of high water is tolerably uniform from year to year, so as to be in a manner normal. Supplied chiefly from melting snows at greater and greater altitudes as the season advances, it persists with only slight fluctuations until the supply is exhausted, when the water slowly falls to its low-water mark, where it remains the rest of the year with only a small amount of variation, because the rainfall is so light. There thus exist two distinct and somewhat uniform conditions of the water, each occupying its regular part of the year. Owing to this regularity of high water, the maximum bed of the river produced by it is somewhat uniform and clearly marked, while it also bears a tolerably uniform relation to the deeper channel represented by the low-water state. Examined in time of low water, this river-bed seems to be three or four times as wide as the river itself. The stream, then, usually flows in serpentine curves which cross and recross the bed. The bed itself is also crooked much as is the channel, only its curves are as much longer as it is wider. The whole valley is usually also winding with much more ample curves, and the river-bed crosses and recrosses it in a manner similar to that in which the channel crosses and recrosses the bed. The river itself generally hugs one of the banks of the bed, but it is always at a curve, or bend, such as will tend to wear the bed on the convex side and thus render it more crooked. The distance traversed by the channel in crossing from one side of the bed to the other is small, compared with the distance traversed while in close contact with the bank of the river-bed, which it is perpetually extending into the general valley. The reason why it does not constantly grow wider is, that on the abandoned side the surface is being constantly raised by deposits of material which the water, more sluggish on this side, can no longer hold. As the river shifts its position in the valley, a strip of land of varying width is formed each year to be gradually assimilated to the permanent valley (see Diagram No. II).

If, now, we take the more general view and regard the entire valley as one homogeneous product, we can better study the process by which it has been formed. Beginning with the channel of the river we shall find that, except where crossing the bed, its cross-section presents a figure approaching more or less closely to a right-angled triangle with the right angle at the bottom, or deepest place. One side will then be formed by a steep wall or bank, which may become perpendicular above the surface of the water, but is not usually so below. The other side of the triangle represents the general bottom of the river, which gradually grows more shallow toward the remote side of the river-bed.

At the deepest point, fresh erosion or corrosion is taking place, while the steep bank adjacent is being rapidly worn away (see Diagram No. III).

The features to be described can only be satisfactorily observed in time of low water. The bank above the river on the deep side is then generally very high, often rising perpendicularly twenty feet or more above the surface of the water. This high bank, thus exposed to the view of the navigator in the river, affords a most excellent opportunity of studying the manner in which the material composing the general valley has been deposited, the various agencies that combined to form the deposit, and the approximate time required for the accumulation of a given thickness of this alluvium.

These walls of loose earth are always very conspicuously stratified, the layers having various thicknesses and different colors. As many as a dozen distinct strata can usually be seen, often very definitely marked off from one another. The color of these layers enables the observer to determine, with considerable certainty in any case, whether it was due to a wash from the neighboring hills, whose color can be directly compared, or to a deposit from the river itself, brought in time of flood from points higher up, or, as is often the case, from vegetable mold which long immunity from disturbance has allowed to accumulate. Some idea of the time occupied in the total deposit may be formed from the presence of forests of cottonwood (*Populus monilifera*, Ait.) which line the river. These trees are sometimes of great size, measuring three or four feet in diameter, and, although the cottonwood is a rapidly growing tree, there can be no doubt that many of the trees are two or three hundred years old. But the mere presence of these forests standing upon the surface of the latest stratum of the general valley is by no means the only time-measure we have. A careful observer, though merely walking among them, might perceive that some of them have their bases buried to some little depth with alluvial earth or vegetable mold. This fact, which would escape any one who was not specially looking for evidences of it, becomes striking when the edges of the strata are viewed from the river.

As the river wears away the previously formed deposits of its valley, it at length approaches the portion that has had time to become covered with these forests. Undaunted, it attacks this portion also, and begins the work of felling the trees. Their roots are laid bare, the solid earth on which they have stood for ages is swept away, and one after another these ancient giants succumb to the rapacity of the waters, and fall powerless into the raging current. Every step in the process by which this result is accomplished may be seen by watching these eroded banks while floating down the stream. The river, as it passes one of these doomed forests, is choked with snags, through which the surging waters roar, and among which it is extremely difficult and often dangerous to guide a boat. These snags are of all

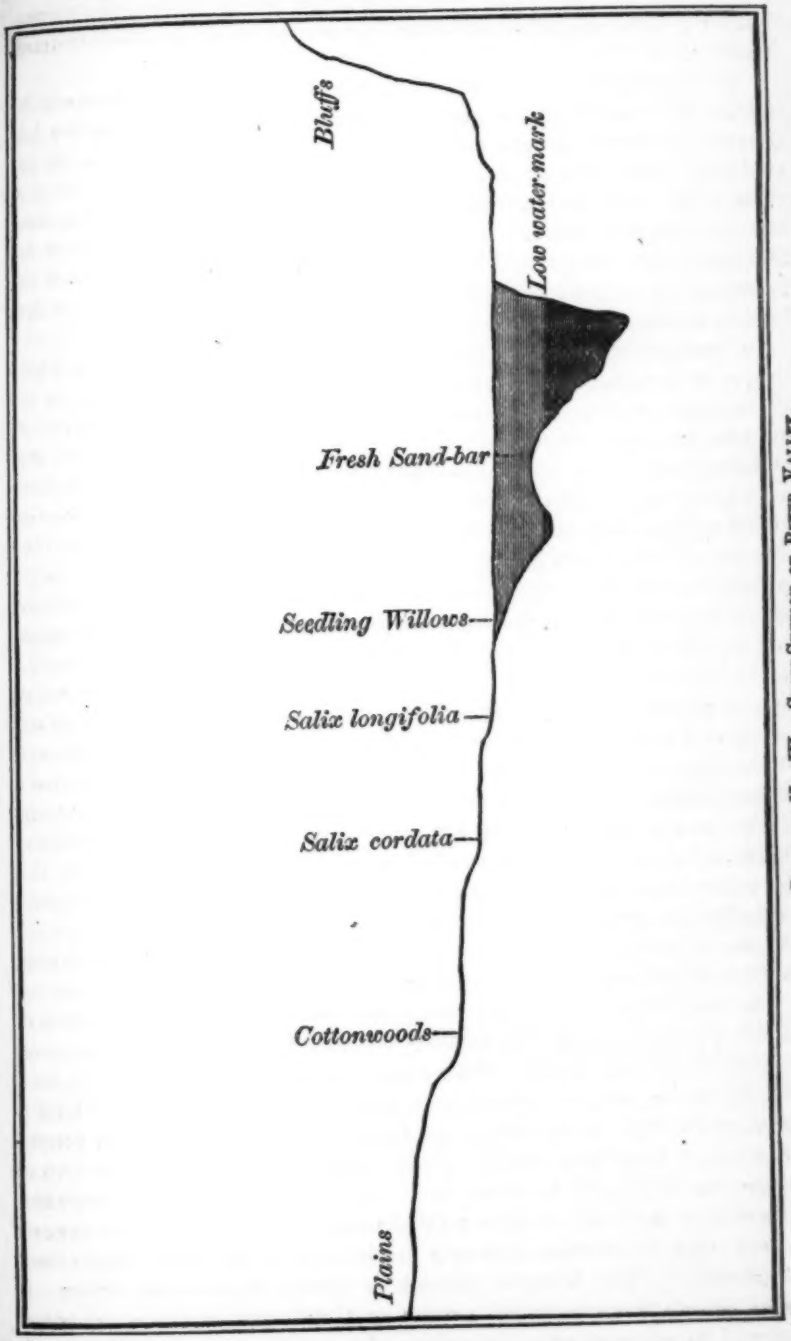

DIAGRAM No. III.—CROSS SECTION OF RIVER VALLEY.

ages, from the old "sawyers" that have bowed before the current with rhythmic regularity perhaps for centuries, to the freshly-felled monarchs still bearing their green leaves of the season.

But the fact of chief interest is the presence of trees on the brink of these eroded walls, whose still living and healthy trunks are laid bare to a depth of several feet below the present surface of the ground. In some cases the subterranean portion occupies as many as four or five feet of the base of the trunk, descending through a number of distinct strata. But even at much greater depth there are frequent and unmistakable relics of ancient forests long since destroyed, or, as it were, buried alive. At depths of ten or twelve feet below the present surface, old stumps, with roots and remains of trunks, are brought to light by the inroads of the river. The trees which these represented must have been buried deeper and deeper, in the same manner as existing ones are proved to be undergoing burial, until, unable longer to perform the functions of circulation, they died, and all decayed except these deeply buried parts. Sometimes even these are gone, and naught remains beyond a reddish stain against the vertical wall to mark the spot where once there flourished upon the then surface of the valley a large and healthy tree (see Diagram No. IV).

The method thus far described of studying the mode of formation of the river-valley is that of *analysis*—the observation of the action of the water in disintegrating it. But we may also employ the method of *synthesis*, and study the manifest process of valley-building which takes place simultaneously. The river is always loading up on one side, and unloading on the other. The deepest part of the river near the high banks, as it sweeps round the great bends, is also the swiftest. The current grows slower and slower in the direction of the opposite shore, and at the same time the water grows more and more shallow, until at last a sand-bar is reached gradually rising out of it. If this proves to be the mainland, the case is simple, and we will first consider this simple case. This sand-bar was formed at the last period of high water in the spring and early summer. It therefore consists of sand only, without vegetation. It may have a width of fifty or a hundred feet when it ceases, and a distinct rise occurs, with a little terrace of sand, thickly covered with seedling willows, all belonging to one species (*Salix longifolia*, Muhl.), and bearing no other vegetation. The sand is still damp, being saturated with water from the river. This land is two years old. A short distance farther back another similar terrace is reached, bearing a thicket of this same willow, but it is now two to four feet high, and fruit-bearing. The land is here three years old. Another remove brings us to a third terrace, having larger willows and some other vegetation, such as is not injured by periodical floods flowing over it. This four-year-old soil is darker in color and firmer. It may complete the river-bed proper, or there may be still another terrace. As we recede from the river, these old river-bed marks become

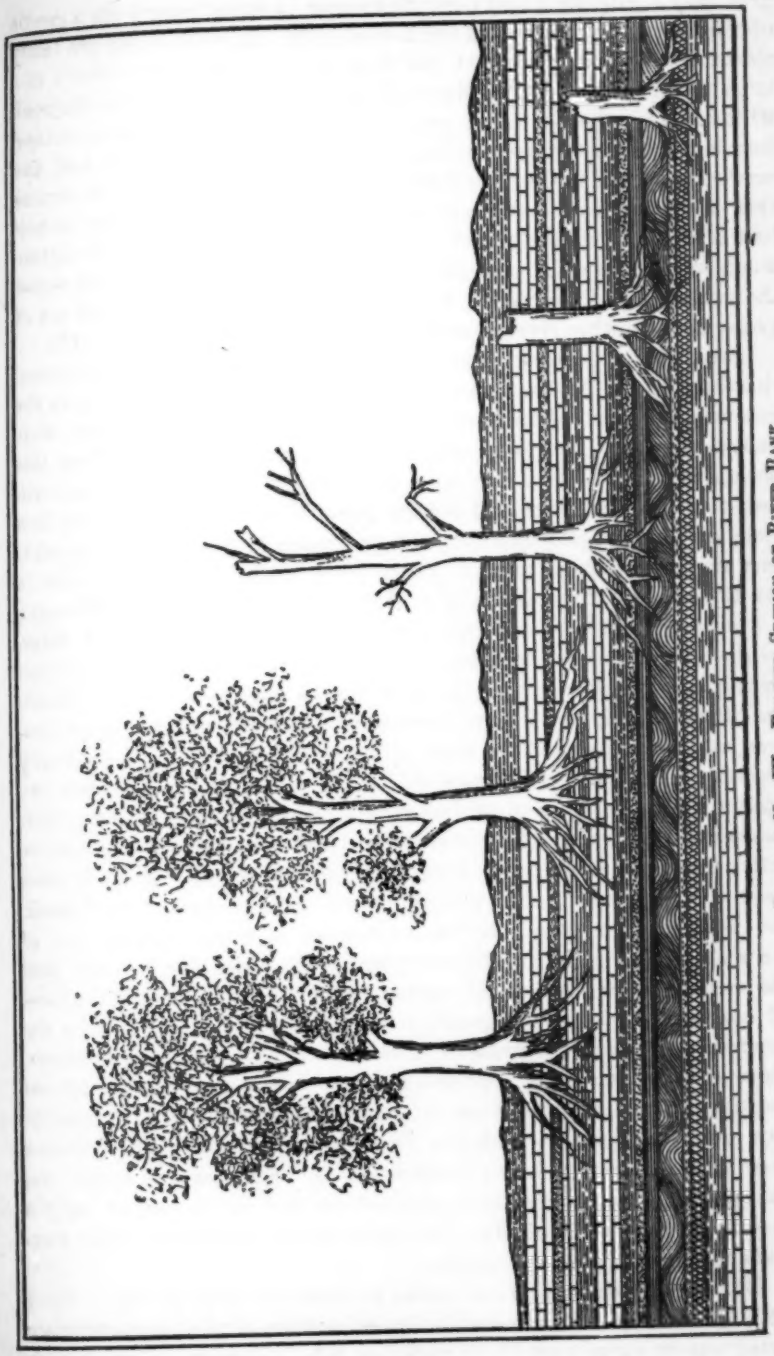

DIAGRAM No. IV.—EXPOSED SECTION OF RIVER BANK.

gradually obliterated, and the valley seems to slope away with a gentle upward curve to the foot of the lowest hills. As soon as we are fairly out of the present river-bed the little willow gives way entirely to a large one (*Salix cordata*, Marshall), popularly known as the diamond willow. This species often grows very dense and in large clumps, forming an almost impenetrable thicket. It monopolizes the soil, and renders approach to the river difficult. It is at a point still more remote that the growth of cottonwoods begins, and these may form a belt half a mile to a mile in width. From the outer edge of these cottonwood-forests the plain commences, and stretches back, not only across the remainder of the valley, but far away in an uninterrupted sea of grass, until another river system is reached (see Diagram No. III).

Such, in its general outline, may be conceived to be the normal character of the Missouri and Yellowstone Rivers after they pass the mountainous part of their course and enter the portion where wide valleys prevail. But there are, of course, many deviations from this normal type. The fires may have destroyed the cottonwoods and willows that line the river and occupy most of its bed, and an unbroken plain may extend down to the sand-bars upon its banks. These sand-bars may form islands around which quite brisk currents flow even in the dry season. Sometimes, as at Spread-Eagle Bar, on the Missouri, a number of such bars occur, with shallow currents between them, wearing them away along clean-cut faces, and shifting their position from place to place, giving great width to the river. Large islands are often formed, which have accidentally escaped the denuding process, and, being beyond the reach of fires, become covered by a heavy growth of timber. Sometimes the bed of the river lies between two similar high banks, more or less central in the valley, showing that, instead of continuing to approach the bluffs on one side, its erosive action has from some cause been arrested or reversed. In such cases there is occasionally found a nearly equal current against each bank, but usually, even here, the main channel is snug against one of the walls, which it is rapidly carrying away, while the opposite wall has an ancient or obsolete appearance, with shoals or bars at its base. Of course, the entire configuration of the country is modified by the occurrence at short intervals of tributary streams with their valleys. These streams, in spring, contain considerable water; but, throughout the summer and autumn, most of them are perfectly dry, at least at their point of junction with the river, whatever water they receive from rains or springs being evaporated in their passage across the arid plains. One is greatly astonished to find no water, or only a rivulet, at the mouths of what are called rivers, and which drain hundreds of square miles of country.

But the Missouri and Yellowstone themselves never go dry. They are large and rapid streams at the dryest seasons of the year, and their turbid waters surge past like a resistless tide. They wear down their

valleys by slowly crossing and recrossing them, like a turner's chisel. Once at their limit on a given side, they may be imagined to halt and turn back. The form of the bottom is changed and the point of greatest activity transferred from one side to the other; the sand-bars are first removed, and then the willow-belt is carried away; next they attack the forest of cottonwoods, and mercilessly sacrifice these; still undaunted, they invade the higher parts of the valley, wear away wide stretches of plain, and slowly march up to the foot of the adjacent hills and mountains, which they also attack and undermine, until, checked by the increasing quantity of *dêbris*, and driven back by the very magnitude of their own trophies, they beat a retreat, only to repeat for the thousandth time the process which we have thus hastily sketched.

AIMS OF THE STUDY OF ANTHROPOLOGY.*

By Professor WILLIAM H. FLOWER, F. R. S.

ONE of the great difficulties with regard to making anthropology a special subject of study, and devoting a special organization to its promotion, is the multifarious nature of the branches of knowledge comprehended under the title. This very ambition, which endeavors to include such an extensive range of knowledge, ramifying in all directions, illustrating and receiving light from so many other sciences, appears often to overleap itself and give a looseness and indefiniteness to the aims of the individual or the institution proposing to cultivate it.

The old term ethnology has a far more limited and definite meaning. It is the study of the different peoples or races who compose the varied population of the world, including their physical characters, their intellectual and moral development, their languages, social customs, opinions, and beliefs; their origin, history, migrations, and present geographical distribution, and their relations to each other. These subjects may be treated of under two aspects: first, by a consideration of the general laws by which the modifications in all these characters are determined and regulated—this is called general ethnology; secondly, by the study and description of the races themselves, as distinguished from each other by the special manifestations of these characters in them. To this the term special ethnology, or, more often, ethnography, is applied.

Ethnology thus treats of the resemblances and differences of the modifications of the human species in their relations to each other, but anthropology, as now understood, has a far wider scope. It treats of

* From the President's address, delivered at the anniversary meeting of the Anthropological Institute of Great Britain and Ireland, January 22, 1884.

mankind as a whole. It investigates his origin and his relations to the rest of the universe. It invokes the aid of the sciences of zoölogy, comparative anatomy, and physiology; and the wider the range of knowledge met with in other regions of natural structure, and the more abundant the terms of comparison known, the less risk there will be of error in attempting to estimate the distinctions and resemblances between man and his nearest allies, and fixing his place in the zoölogical scale. Here we are drawn into contact with an immense domain of knowledge, including a study of all the laws which modify the conditions under which organic bodies are manifested, which at first sight seem to have little bearing upon the particular study of man.

Furthermore, it is not only with man's bodily structure and its relations to that of the lower animals that we have to deal; the moral and intellectual side of his nature finds its rudiments in them also, and the difficult study of comparative psychology, now attracting much attention, is an important factor in any complete system of anthropology.

In endeavoring to investigate the origin of mankind as a whole, geology must lend its assistance to determine the comparative ages of the strata in which the evidences of his existence are found; but researches into his early history soon trench upon totally different branches of knowledge. In tracing the progress of the race from its most primitive condition, the characteristics of its physical structure and relations with the lower animals are soon left behind, and it is upon evidence of a kind peculiar to the human species, and by which man is so pre-eminently distinguished from all other living beings, that our conclusions mainly rest. The study of the works of our earliest known forefathers, "prehistoric archæology," as it is commonly called, although one of the most recently developed branches of knowledge, is now almost a science by itself, and one which is receiving a great amount of attention in all parts of the civilized world. It investigates the origin of all human culture, endeavors to trace to their common beginning the sources of all our arts, customs, and history. The difficulty is what to include and where to stop; as, though the term "prehistoric" may roughly indicate an artificial line between the province of the anthropologist and that which more legitimately belongs to the archæologist, the antiquary, and the historian, that the studies of the one pass insensibly into those of the other is an evident and necessary proposition. Knowledge of the origin and development of particular existing customs throws immense light upon their real nature and importance; and, conversely, it is often only from a profound acquaintance with the present or comparatively modern manifestations of culture that we are able to interpret the slight indications afforded us by the scanty remains of primitive civilization.

Even the more limited subject of ethnology must be approached

from many sides, and requires for its cultivation knowledge derived from sciences so diverse, and requiring such different mental attributes and systems of training, as scarcely ever to be found combined in one individual. This will become perfectly evident when we consider the various factors or elements which constitute the differential characters of the groups or races into which mankind is divided. The most important of these are:

1. Structural or anatomical characters, derived from diversities of stature, proportions of different parts of the body, complexion, features, color and character of the hair, form of the skull and other bones, and the hitherto little-studied anatomy of the nervous, muscular, vascular, and other systems. The modifications in these structures in the different varieties of man are so slight and subtile, and so variously combined, that their due appreciation, and the discrimination of what in them is essential or important, and what incidental or merely superficial, require a long and careful training, superadded to a preliminary knowledge of the general anatomy of man and the higher animals. The study of physical or zoölogical ethnology, though it lies at the basis of that of race, is thus necessarily limited to a comparatively few original investigators.

2. The mental and moral characters by which different races are distinguished are still more difficult to fathom and to describe and define, and, although the subject of much vague statement, as there are few people who do not consider themselves competent to give an opinion about them, they have hitherto been rarely approached by any strictly scientific method of inquiry.

3. Language.—The same difficulties are met with in the study of language as in that of physical peculiarities, in the discrimination between the fundamental and essential and the mere accidental and superficial resemblances; and in proportion as these difficulties are successfully overcome will the results of the study become valuable instead of misleading. Though the science of language is an essential part of ethnology, and one which generally absorbs almost the entire energies of any one who cultivates it, its place in discriminating racial affinities is unquestionably below that of physical characters. Used, however, with due caution, it is a powerful aid to our investigations, and, in the difficulties with which the subject is surrounded, one which we can by no means afford to do without.

4. The same may be said of social customs, including habitations, dress, arms, food, as well as ceremonies, beliefs, and laws, in themselves fascinating subjects of study, placed here in the fourth rank, not as possessing any want of interest, but as contributing comparatively little to our knowledge of the natural classification and affinities of the racial divisions of man. When we see identical and most strange customs, such as particular modes of mutilation of the body, showing themselves among races the most diverse in character and

remote geographically, we can not help coming to the conclusion that these customs have either been communicated in some hitherto unexplained manner, or are the outcome of some common element of humanity, in either of which cases they tell nothing of the special relations or affinities of the races which practice them.

This subject of ethnography, or the discrimination and description of race characteristics, is perhaps the most practically important of the various branches of anthropology. Its importance to those who have to rule—and there are few of us now who are not called upon to bear our share of the responsibility of government—can scarcely be overestimated in an empire like this, the population of which is composed of examples of almost every diversity under which the human body can manifest itself. The physical characteristics of race, so strongly marked in many cases, are probably always associated with equally or more diverse characteristics of temper and intellect. In fact, even when the physical divergences are weakly shown, as in the case of the different races which contribute to make up the home portion of the empire, the mental and moral characteristics are still most strongly marked. As it behooves the wise physician not only to study the particular kind of disease under which his patient is suffering, and then to administer the approved remedies for such disease, but also to take into careful account the peculiar idiosyncrasy and inherited tendencies of the individual, which so greatly modify both the course of the disease and the action of remedies, so it is absolutely necessary for the statesman who would govern successfully, not to look upon human nature in the abstract and endeavor to apply universal rules, but to consider the special moral, intellectual, and social capabilities, wants, and aspirations of each particular race with which he has to deal. A form of government under which one race would live happily and prosperously would to another be the cause of unendurable misery. No greater mistake could be made, for instance, than to apply to the case of the Egyptian fellah the remedies which may be desirable to remove the difficulties and disadvantages under which the Birmingham artisan may labor in his struggle through life. It is not only that their education, training, and circumstances are dissimilar, but that their very mental constitution is totally distinct. And when we have to do with people still more widely removed from ourselves—African negroes, American Indians, Australian or Pacific islanders—it seems almost impossible to find any common ground of union or *modus vivendi;* the mere contact of the races generally ends in the extermination of one of them. If such disastrous consequences can not be altogether averted, we have it still in our power to do much to mitigate their evils.

All these questions, then, should be carefully studied by those who have any share in the government of people of races alien to themselves. A knowledge of their special characters and relations

to one another has a more practicable object than the mere gratification of scientific curiosity; it is a knowledge upon which the happiness and prosperity, or the reverse, of millions of our fellow-creatures may depend.

WHERE AND HOW WE REMEMBER.

By M. ALLEN STARR, M. D.

IF you examine the brain of a dog, or an ape, or a man, you will see that it is made up of two kinds of substance, gray and white. The gray substance, which is formed of round bodies of nervous matter called nerve-cells, is spread out in a thin layer over the entire surface of the brain. The white substance constitutes the center and body of the organ, and consists of white threads or nerve-fibers which pass in various directions through the brain and end in the cells of the gray matter. It is the office of the white fibers to convey messages; it is the office of the gray cells to dispatch them, or to receive and register them.

If a brain be properly torn apart, it can be shown that many of the white threads are collected into bundles. These bundles, each of which contains many thousand threads, can be separated from one another and followed to their terminations. It will then be found that each bundle, or tract, as it is called, connects some one organ of the body with some one region of the gray matter on the surface of the brain. For example, one tract joins the muscles of one half of the body with the lateral part of the opposite half of the brain; another ascends from the surface of the body, being made up of many fibers, each of which comes from one little area of skin, and this tract ends in the surface of the brain just behind the first one; another bundle comes from the eye and goes to the posterior part of the brain. So too the ear, the nose, the tongue, send in their bundles, and each of these goes to a definite and separate region of the surface. And thus, as every part of the body is connected by its own tract with its own part of the gray matter, we can imagine upon the surface of the brain a map of the entire body laid out, and can say, as Meynert does, that the surface of the body is *projected* upon the surface of the brain.

Each of the little white threads, like an electric wire in a cable, is insulated from every other by a sheath. It is therefore impossible for a message sent from one end of the thread to leave it; the message must go to the other end of the thread. Therefore, an irritation set up in any organ of the body is always transmitted to that part of the brain with which the organ is joined, and can not reach any other part directly, although it may do so indirectly, by means of association fibers which join the different regions with one another. The anat-

omy of the brain, thus studied, gives a clear indication that the different regions of its surface govern different organs of the body, and that each region has a distinct function to perform.

It is an admitted fact that an irritation set up at one end of a sensory nerve and sent to the brain produces a change of state in the gray cells which receive it. That change of state is known to us as the conscious perception of a sensation. The conscious perception does not occur in the organ irritated, nor in the nerve which carries the irritation. It occurs in the brain. The perception of an object seen does not take place in the eye, nor in the optic nerve, but in the posterior part of the brain where the tract from the eye terminates in gray cells. In like manner each sensation is consciously perceived in that part of the brain with which the sensory organ is connected whose irritation produced the sensation.

Being perceived, the sensation is in some way registered and preserved, so that when a second similar irritation is sent inward we not only perceive it, but recognize it as a matter of former experience. But, independently of a second perception, we have evidence that the first is preserved in the fact that we can call it up to consciousness by a voluntary effort, and make it, by means of memory, an object of thought. In both these processes the same part of the brain is in action which originally perceived the sensation. But, as sensations are perceived in various regions, it becomes evident that memories are stored up in various regions. If this is so, our various kinds of memory must be independent of each other, and one may be lost while others remain. We shall soon see that this is the fact.

If you lay bare the brain of a dog, and carefully cut out all the posterior part of both halves or hemispheres, you will find, when the dog recovers from the operation, that it is totally and permanently blind. It can smell, and hear, and taste. It can run about, and can perceive sensations of all kinds except those of sight. If from the brains of other dogs you cut out other parts, but leave the posterior part untouched, sight will not be affected in any case. These physiological experiments show that perceptions of sight occur in the posterior parts of the brain, the parts to which we have already traced the white threads from the eye.

If, instead of cutting out the whole of the posterior part of the brain, you select the central portion of the posterior part, leaving a ring of tissue about it uninjured, the result is more interesting. (See Fig. 1, A,.) After a few days, when the wound is healed, you will find that the dog's hearing, smell, taste, motion, and general sensation are in no way affected. The animal runs about the room, and, unlike the first dog, either avoids or jumps over any obstacle which may be put in his way. He can therefore see the obstacle. But the sight of other dogs, or of men, whom he used to recognize with signs of pleasure or dislike, no longer affects him at all. However hungry or thirsty he

may be, he no longer looks for his food and water in their usual places, and when they are put before him he does not seem to know them as food and water until his nose is put into them, when he recognizes them by other senses than sight. The sight of the whip, which used to make him run into a corner, does not frighten him any more, though he jumps when he hears it snap. He used to give his paw when the hand was held out for it. Now he will not do so until the word paw is spoken, when he holds it up as before. The dog is not blind, but he has lost the power of recognizing objects formerly recognized by sight. He has been deprived, by the operation, of his sight-memory pictures, or sight-imaging power. He has been put back, as far as one sense is concerned, into the condition in which he was when born—that is, destitute of knowledge acquired by sight-perception. He acts just like a puppy; for he soon begins to smell and lick objects in an inquiring way, and to run to and examine curiously things with which he was formerly familiar. He sees these things, he learns again to know them; in a word, he begins at once to lay in a new store of memory-pictures. It is only necessary to put his nose into water a few times; after that he looks for and finds it when he is thirsty. Then he begins to know his master. The whip soon becomes again a dreaded object. And in the course of two or three months he has gained a new set of memories and recognizes objects just as before the operation.

In the first dog, the entire posterior part of the brain was removed, and the dog was made permanently blind. In the second dog, a portion of this part of the brain was cut out, and the dog was deprived of his sight-memory. He was, however, able to recover. And, if by successive operations the experiment be repeated on the same dog, it will be found that recovery is always possible until the entire posterior part of the brain is removed, when, like the first dog, he becomes permanently blind. The recovery then was possible because around the area cut out there was left a ring of gray matter which was in connection with the eye; and in this ring of gray matter, which formerly contained no memory-pictures, the new memory-pictures were stored. All the posterior part of the brain in the dog is, therefore, a *potential* area for sight-memories. The *actual* area of sight-memories occupies only a part of the potential area. If the actual area is cut out, but a part of the potential area remains, the dog is temporarily deprived of sight-memory, but can recover. If the potential area is entirely extirpated, the dog remains blind, and can never regain his memories. The distinction between actual and potential memory is important, as we shall see when we come to similar phenomena in man.

The experiments just described were first made by Hermann Munk, Professor of Physiology in the University of Berlin, and they have been confirmed by many other experimenters. What has thus been proved of the location of perception by sight, and of sight-memories in the posterior part of the brain, has also been proved of other senses

and their memories. The perception of sounds and sound-memories are destroyed when the lower lateral part of the brain (the temporal region) is injured, but are not affected as long as this region remains intact. When the anterior portion of this region is destroyed, the animal becomes deaf to sounds of a low pitch; when the posterior portion is injured, high notes are no longer heard. If the region is entirely extirpated, the animal is totally and permanently deaf. If it is only partly extirpated, the animal loses all memory of words or commands formerly recognized, attaches no meaning to the cry of its puppies, to the snap of the whip, or to its master's whistle. The perception of touch and its memories are destroyed when the upper lateral portion of the brain is injured (the parietal region). Voluntary motion is suspended when the antero-lateral portion is destroyed. If the destruction of this part is complete, the paralysis is permanent; if not, recovery is possible. In all these regions the distinction between actual and potential obtains: if the actual area only is cut out, the acquisitions already gained are lost; but, as long as some of the potential area remains, the power to acquire is present and recovery is possible.

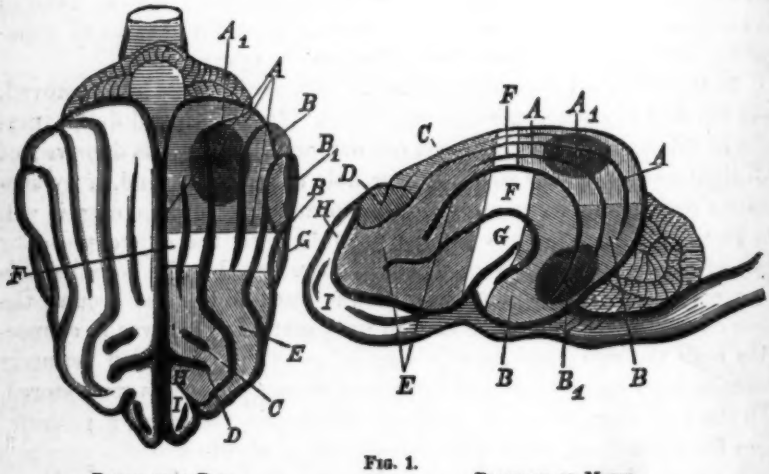

FIG. 1.

BRAIN OF A DOG. DIAGRAM OF MUNK.

A. Visual area; *potential* area of sight-memories.
A_1. Visual area; *actual* area of sight-memories before operation.
B. Auditory area and potential area of sound-memories. B_1. Actual sound-memories.
C. Area governing motion and sensation in hind-leg of the opposite side.
D. Area governing motion and sensation in fore-leg of the opposite side.
E. Area governing motion and sensation in head of the opposite side.
F, *G*. Area governing motion of the muscles of the eye and ear respectively of the opposite side.
H, *I*. Area governing motion and sensation in neck and body of the opposite side.

Thus, by experiment, a number of regions are mapped out on the surface of the brain and the function of each is determined. When the results of the physiologists are compared with those of the anatomists, they are found to agree. The area of the brain which the physiologist has shown to govern sight has been shown by the anatomist

to be connected by means of insulated white nerve-fibers with the eye. The area which, one says, governs touch, the other says is connected with the skin. The area which one proves to be concerned with voluntary movements, the other finds to be joined to the muscles. Thus the two independent lines of evidence unite in indicating that each region of the brain has its own work to do, its own memories to preserve.

While the anatomical evidence in favor of the localization of memories is as strong in the case of man as it is in that of the dog or ape, the physiological evidence is wanting. Physiologists lament that they can not experiment upon man, and psychologists are slow to admit that these experiments throw any light upon man's mind and its action. Just here, however, the study of disease comes in to help out our knowledge. Disease may be regarded as an experiment of Nature to satisfy both physiologists and psychologists, and its results are the more satisfactory, since man is an animal who can describe his sensations during the experiment, as no other animal can. The nature and value of the evidence for the localization of memories to be derived from the study of disease will be clear after the blood-supply of the brain in man is understood. Every artery divides and subdivides as it passes outward from the great central artery of the body—the aorta—so that the vascular system may be likened to a tree, with trunk, boughs, branches, and twigs. Each terminal division of an artery supplies with blood a little cone-shaped mass of brain, the base of the cone being the gray surface of the brain, and its apex being the point of entrance of the little artery. In the brain the terminal branches of the arteries do not run into each other, as in some organs, so that each little cone, like the leaf on the tree, is independent of adjacent cones and hangs upon its own arterial twig. Now, it is evident that anything which plugs up the artery is going to cut off the blood, and therefore the nutriment from the little cone of brain, and then the little cone will wither and die. The larger the artery plugged, the greater the surface of brain destroyed. This is the process of disease known as embolism or thrombosis. But such a destruction of brain-tissue in man corresponds to the artificial destruction of brain-tissue in the dogs experimented upon, with this advantage in the case of man, that the shock of the operation is avoided. The experiments of Nature and of the physiologist are therefore parallel. The only difference is in the order of the observation. The physiologist cuts out a definite part and observes the result. The pathologist observes the result of Nature's experiment by watching the symptoms of his patient, and, after the patient's death, he can ascertain the position of the part diseased. Now, if the old theory be true, according to which the brain acts as a whole, and its various parts do not possess distinct mental functions, a limited area of disease in one part may impair the mental powers but will not produce a loss of one function. If, on the contrary, the new theory

be true—the one to which the anatomical arrangement and the physiological experiments point—that each part of the brain has its own work to do, a limited area of disease will interfere with the work of the part diseased—will produce a loss or impairment of one function, and will not affect all the powers.

The following instance shows that pathology supports anatomy and physiology, and that the localization of functions and memories is no longer a matter of question among scientists:

Not long ago a man was brought into Bellevue Hospital, in this city, suffering from fever, headache, delirium, and stupor, which had developed after a blow upon the head. In addition to these symptoms, he had a paralysis of the muscles on the back of the fore-arm, so that he could not raise his left hand. The general symptoms indicated the presence of an abscess in the brain. To the surgeon, familiar with the anatomy and with the physiological experiments upon animals, the paralysis of the arm-muscles indicated that the abscess was situated in that part of the brain whose function it was to raise the hand. He therefore sawed through the skull over the supposed site of the abscess, and, although the hole which he made was only large enough to admit his little finger, the abscess was found lying just beneath it, and was emptied.

Such a case shows that the study of localization may aid in saving life. The following cases of loss of a definite kind of memory, occurring suddenly, and accompanied by symptoms which indicated the situation of the disease in the brain, remind one very forcibly of the physiological experiments described, and afford positive proof that powers of sensation and memory, as well as the power of motion, may depend upon the integrity of definite regions of the brain:

An intelligent gentleman, while playing billiards, suddenly became aware of the fact that he could see but one half of the ball at which he was aiming. He had become blind in the right half of both eyes. Soon after, on attempting to read, he found, much to his surprise, that he could not read. He could see the letters and words, but they conveyed no meaning to his mind, and appeared to him as so many forms—just as a set of Chinese letters do to us. He had lost the power to recognize written and printed language. Singularly enough, he could write as well as ever, but it was impossible for him to read what he had just written. The memory of the motion involved in producing a letter remained, the memory of its appearance was gone. The memory of the motion served to take the place to some degree of the lost memory-pictures, for, when asked to read a word, he would bring up his hand to the page and with his finger trace the form of the letter, and then name it. It was evident that the only means he had of recalling a letter was by going through the motion necessary to write it—in other words, by calling into play his motor-memories. As he was more accustomed to trace written than printed letters, it took him a

longer time to recall by tracing printed than written words. But this was not his only defect of memory. He found that many objects formerly perfectly familiar were no longer recognized by sight. He was well acquainted with the streets of Paris, but on going out he now looked at the houses and streets as at those of a new, unknown city, and he was unable to find his way about. The loss of memory did not consist simply in a failure to recognize objects seen, it involved his power to call up to his mind objects formerly well remembered, places well known, faces, scenes of his childhood, etc. The blindness in the right half of both eyes indicated that the disease was situated in the posterior part of the left half of the brain, for this has been found diseased in nearly thirty cases of similar defects in vision in which an examination of the brain was made. The loss of memory of objects seen indicated that in that part of the brain in which the perception by sight occurs were located nerve-cells whose integrity was necessary to the existence of the sight-memories lost. The case demonstrated conclusively that sight-memories lie in the posterior part of the brain. The mental vigor of this man was good. His other faculties, his other perceptions and memories, were not affected. He was not paralyzed; but, as far as reading was concerned, he had been put back into the exact condition in which he was when as a boy he began to learn to read. And when the writer saw him last, in the wards of Charcot's great hospital in Paris, he was studying away at his alphabet like a school-boy of six years.*

This is not an isolated case. In the same hospital, at the same time, was another gentleman who had been remarkable for the excellence of his memory. It had always been possible for him to acquire easily, and he had only to read a passage carefully in order to remember it verbatim. He also had considerable talent in sketching, and was in the habit of drawing any figure or view which pleased his eye. His memory of music, or of things heard, was less active and reliable than his visual memory. One day he suddenly noticed a peculiar change in his power of mental action, which alarmed him very much. He found that everything about him seemed strange and unfamiliar. His visual memory was entirely gone, so that he no longer recognized objects or faces, and could not call up to his mind the forms or colors of well-known things. The town in which he lived seemed an unknown place. He looked at its streets, its houses, its statues with curiosity, as at those of a strange city. The same was true of Paris, to which he came for medical advice, and where to his surprise he could not find his way about. At the same time he lost the power to sketch, being unable to remember the object to be drawn long enough to draw it, and being unable to recall the appearance of lines and shading in a picture. He found that he could not recall the faces of his wife and children, and when they came to him he only

* This case was fully reported by Charcot, in the "Progrès Médicale," May, 1883.

recognized them by the sound of their voices. He even forgot his own appearance, and, being in a large public gallery, and seeing, as he supposed, some one in a doorway barring his passage, he stepped forward to ask the stranger to let him pass, when by the motions he realized that it was his own figure seen in a large mirror. This loss of visual memory extended to memories of his childhood as well as to those acquired recently. It interfered much with his power of reading. In reading a book or in adding a column of figures it was necessary for him to have recourse to movements of articulation of his tongue and lips in order to understand what he read or in order to add. While formerly he could remember easily what he read, he now was obliged to read aloud anything he desired to commit to memory, and thus to learn it by impressing his auditory memory. An interesting detail of the affection was the fact that in his dreams he no longer saw objects, but merely heard sounds or words.*

Thus he had been deprived entirely of one class of memories, while all others were still at his command. As a consequence, there had come about a complete change in his character, which can easily be understood when one considers how largely one's thinking is made up of the comparison of one set of memories with another, and how frequently the whole circuit of one's thoughts and actions centers about one group of memories. This man was an artist, and in a moment all the powers, the result of long study and labor, which enabled him to perform and enjoy his life-work, were taken away. In this case, as in the first one related, the disease must have been situated in that part of the brain where visual memories are stored, viz., in the posterior part.

Such a loss of visual memories may be temporary, as is well illustrated by the case of a city district messenger-boy, who found on several occasions that he suddenly lost his way and could not recognize streets with which he was usually familiar, so that he was obliged to ask a policeman to take him to his home; where, however, in the course of a few hours he recovered his memory of places and of faces which he had lost. In this case, which may be regarded as one form of epilepsy, the loss of memory can be explained by the hypothesis that a spasm of the arteries occurred in the posterior part of the brain, just as such a spasm in those of the face gives rise to a sudden pallor.

Visual memories are not the only ones to be temporarily or permanently lost. There is another class of cases whose study gives unmistakable evidence of the localization of memories in that part of the brain in which the original perception occurred. It has been stated that the auditory nerve sends a tract to the lower lateral portion of the brain (the temporal region), and that destruction of this region in animals gives rise to deafness. When this part is injured by disease in man, a peculiar condition is observed, known as word-deafness.

* This case is reported in the "Progrès Médicale," July 18, 1883.

This can be readily explained by a review of what occurs in answering a simple question. When you answer a question, the following processes have taken place: 1. You have heard the words of the question. 2. The words have been recognized as known words, and have awakened a corresponding concept. 3. The concept has started a train of thought which has led you to a conclusion. 4. You have formulated your conclusion in words. 5. You have voluntarily set in motion a mechanism consisting of your throat, lips, and tongue, to speak the words. 6. This mechanism has responded to the effort, and has produced the sound of your reply. Now, any one of these processes may be interfered with, in which case you will not answer the question. If you are deaf, you may not hear it. If it is spoken in a language which you do not understand, the words will fail to be recognized, as the sounds will not awaken any memory or concept.

But the words addressed to a child are at first mere sounds to him, and it is only by repeated reiteration of the word in connection with the object or act indicated by it that the child has acquired a knowledge of its meaning. If these acquired bits of knowledge stored up in the memory in childhood are blotted out, the meaning of the word will be lost, and the effect will be the same as if the word had never been learned, or as if it were spoken in an unknown language. This is the condition known as word-deafness, or loss of memory of the sound and meaning of words. It is not an uncommon form of brain-disease, and the symptom and the location of the disease have been connected in so many cases that it is now possible to state that in right-handed persons such a condition is due to disease of the left temporal region, and in left-handed persons to disease in the right temporal region. But such a defect will not only prevent one from recognizing a word when spoken, it will blot out the memory of words, and the power of recalling the words which you desire to use. Therefore you will be unable to answer the question, not only because you do not understand it, but because, if you did understand it—as you might be made to do by appropriate gestures—you could not find words in which to reply. Here, then, another special class of memories, to the exclusion of all others, is blotted out by a localized disease.

But let us follow the process a little further. Suppose you have heard the question, and understood its import, and the concept awakened has set in motion a train of thought which has led you to a proper conclusion, since it is to be supposed that you are neither an idiot nor insane, both of which conditions might interfere with this part of the process; and suppose that your conclusion is formulated in words in your mind. You have still to speak the words before your reply is heard. We will pass by a paralysis of the muscles of the throat or tongue, which would, of course, prevent your speaking, and consider the process of setting in action the voluntary centers which govern speech. You have learned to speak by repeated efforts,

at first with imperfect success, later with proper regulation of the tone and effort necessary; which, when acquired, is remembered, so that the words are now clearly pronounced. But this learning to talk is simply the acquiring of memories of definite combinations of muscular action; in a word, of motor-memories. Other examples of motor-memories are the memory of the motions made in playing a musical instrument, swinging Indian clubs, writing, or using various implements of trade. These are all distinct memories, and any one of them alone can be blotted out by disease. But, if the memory of the motions necessary to pronounce the words of your reply is affected, it is evident that you will be as powerless to answer the question as though you did not understand it. If this is the case, the disease will be in a different part of the brain from that affected in the first case. It will lie above and in front of the temporal region, in what is known as the third frontal convolution of the brain. This, too, is established by hundreds of examinations of persons who died with loss of speech.

It thus becomes evident from the study of brain-disease that our visual memories, our auditory memories, our memories of motion, and our memories of speech may each be lost while other memories are unaffected; and further, that a loss of any one of these memories is always due to disease in its own appropriate part of the brain.

One other set of facts remains which confirms in a remarkable manner the theory of the localization of functions. It is well known that organs which are constantly used grow in strength by use. The blacksmith's arm is the favorite example. It is no less true that an organ which is not used withers away. If one carries his arm in a sling for several weeks, it grows thin. Now, a sensory organ, like the eye, is simply a mechanism for the reception and transmission to its corresponding part of the brain of appropriate impulses. Suppose the organ to be destroyed. It is evident that the part of the brain with which it is joined is no longer called into action; it is no longer used, and the result is that it withers. If from a new-born animal you remove an eye, the tract to the posterior part of the brain and that part of the brain will never be called into use, and hence they never develop to a normal size. If a child is born blind, or loses his sight in infancy, the same is true; so that, when in old age he dies, the posterior part of his brain will be found small and shrunken. It is probable that the examination of the brain of a deaf and dumb person would show an atrophy of the speech-centers, although this has not yet been investigated. It is known that if a limb be amputated and the individual lives for twenty years or more, the part of the brain which formerly governed the movements of that limb, and which received sensations from it, will be found shrunken and withered. So that from this class of facts important evidence is derived regarding the parts of the brain which preside over various functions and which preserve their appropriate memories.

If, now, we take models of four brains, and on the first mark out the location of the various areas connected with the various sensory organs as determined by the anatomical connection of the white nerve-threads; on the second mark out the location of the various areas which physiologists have shown to govern various sensory organs; on the third mark out the various areas whose disease produces disturbance of action in the various sensory organs, and loss of memories of perceptions by those organs; and on the fourth mark out the various areas which wither after disease of the various sensory organs—we shall find that upon all four brains the areas belonging to any one organ coincide. We may therefore conclude that each class of sensations

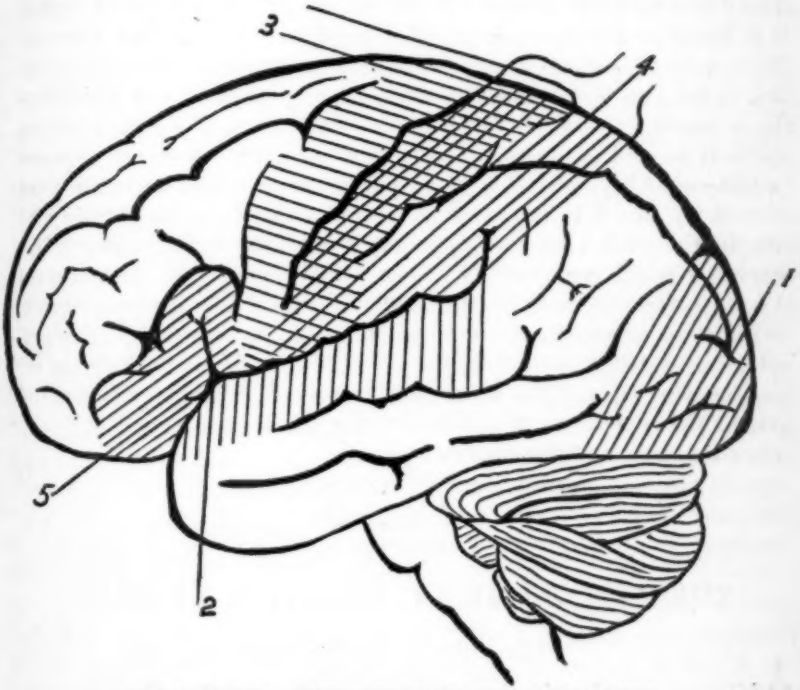

FIG. 2.—OUTLINE OF HUMAN BRAIN, SIDE-VIEW. (After Ecker.)

1. Area of sight and its memories.
2. Area of hearing and its memories.
3. Area of motion and its memories, { upper one third, leg. middle one third, arm.
4. Area of touch and its memories, { lower one third, face.
5. Area of motor speech-memories.

The areas of motion and general sensation coincide to some extent.

and each class of memories has its own definite area of the gray matter on the surface of the brain. Memories of objects seen are located in the posterior part in the occipital region. Memories of sounds heard are located in the lower lateral part in the temporal region. Memories of motions in the limbs, and of touch in those limbs, are located side by side in the central lateral region. Memories of speech

are located in the frontal region. It is therefore a mistake to speak of memory as a single faculty of the mind. It is really an assemblage of distinct memories which we possess, each kind of memory being as different from the others both in its nature and in its location as are the different organs of sense through which the original perception came. These various memories are associated with each other, and this association is secured by means of fibers passing between and joining these different areas. It is also a mistake to give memory as a whole a location in one place as the phrenologists do. Our various memories are scattered over the brain in different regions, being distributed at the time of the perception of the sensation remembered in accordance with the anatomical connection of the percipient organ. It is, finally, a mistake to speak of a good memory or a bad memory. The degree of power to remember differs in our various kinds of memory. One man can remember things seen; another can remember things heard; a third is skillful in the performance of certain motions, and may be said to possess a good motor-memory. A fourth acquires languages readily. So each of us has a stronger and a weaker kind of memory, and it is important to recognize this, in order to train and educate the weaker memory up to the level of the stronger one. The memories which we possess are our actual memories. But around these are areas of gray matter still unoccupied by memory-pictures, and in these potential areas new memories can be stored up. The actual area is always extending, the potential area is diminishing, as we acquire new facts. The wider and more varied our knowledge, the greater the actual area of any one memory, and the more complete our command over our inherent brain-power.

THE ASTRONOMY OF PRIMITIVE PEOPLES.

By G. MÜLLER FRAUENSTEIN.

THE geographical ideas of the lower races, as well as those of civilized people, are of both ethnological and psychological interest, and it is my purpose to devote a few lines to the little-worked field which here presents itself to view. The special subject of my essay will be the ideas concerning the earth and the world formed by primitive peoples, especially the ideas of the form of our planet and of the most important sidereal phenomena; and among primitive peoples I shall, for the purpose of this review, include such half-civilized nations as the Toltecs and Aztecs, and the ancient Peruvians.

Men form different notions of the sky and the earth according to their different points of view. The first appearance of the earth is that of an unbounded surface, and the constructive mind forms a cor-

responding picture of that part of it which is within its vision. Islanders regard their groups as their world, and finish out the picture with fantastic conceptions of the ocean-regions beyond. Highlanders, who, like the ancient Greeks, also see the sea-shore, figure their earth as a cup or a hollowed surface into which the waters run together. The Grecian view held its ground till the Crusades, unaltered even as to its particulars, and is still entertained by the lazzaroni of Naples. People who live in high mountain-regions, and never look upon extensive plains, regard the earth as a sublime range, a massive dome in which peak towers above peak, as the Caucasians do, or as a lofty cone, like the Thibetans. On conceptions like these stand those religious systems which place the seat of the gods, the first home of the human race, or the abode of the dead, among lofty mountains. The Hindoos called Meru, the Thracians Olympus, the residence of the gods. East African tribes, such as the Masais, the Wakamba, the Wakwasi, and the Gallas, say that their gods dwell in Kilimanjaro or Kenia, or a third equally lofty mountain of their regions. And the Indians of the American prairies believe that the happy hunting-grounds of their departed are to be found in the Rocky Mountains.

The conceptions that are formed of the regions of the earth lying outside of vision are equally diversified. In classical antiquity, the earth was imagined to be surrounded by the sea, Oceanus; or the heavenly vault to rest upon mountain-ranges or isolated peaks. The Caroline-Islanders represent the region beyond the Marianne Archipelago, and north of their home, as one in which the sky gradually approaches the earth, and finally rests upon it, but not so closely but what a space is left that a man can creep through. To the Esquimaux of Greenland the sky seems to be a steep, high mountain in the north, around which the stars revolve, while the earth rests upon props that would have decayed, crumbled, and disappeared long ago, if it had not been for the mummery of witches.

From this we may pass to a wider view, which attempts to form an idea of the back side of the earth. The Kamchatkadales conceive that the earth is flat, and that its under side forms a lower world, under which is another land; or as, according to Steller, they expressed it, the earth is the reverse of a sky under which is still another world; so that they consider the world as a vessel of three stories. The conception of the earth as a flat surface lies at the foundation of most of these myths; but there are a few of them that rest on better ideas. According to Newbold, some of the Malays regard the earth as round, like an egg. The Chippewas and Winnebagoes, according to Lawson, and the Duphlas of Assam, regard the earth as a square, with four corners; but the imagination of that shape is exceptional.

What holds the visible world together, and what supports the earth in it, are also questions that have occurred to primitive men; and their attempts to solve these questions also carry with them efforts

to account for particular phenomena of the earth's surface, and such convulsions as earthquakes. Some have tried to compare the earth with an egg in a vessel of water, or with the yolk in the egg; and cosmologies involving this idea are widely spread in Southern Asia, Polynesia, and Melanesia. The Tonga-Islanders say that a god they call Maui carries the earth on his back, and whenever he moves, to turn the other side, or falls asleep, there is an earthquake; and the people were accustomed to beat the ground, with a great cry, to make Maui be quiet. The Khasias, in Assam, say that everything would be destroyed by earthquakes if God did not hold the earth in his hands. The priestly philosophy of the Hawaiians figured the earth as a great mass which the earth-shaker, or earthquake-god, laid upon the central fire. The earth on its side supported the sky by means of two or four pillars. The heaven of the Maories and the Soma of the Vedas are also supported by pillars. The manner in which the sky was in the beginning lifted up on these pillars is carefully described in the Polynesian myth, which relates that the gods Maui and Rua together held the sky on their knees, then lifted it upon their backs, and then on their hands. Other stories relate that, while the sky was resting on the broad leaves of the teva-plant, Rua raised it a little higher up by putting sticks under it, and then the stalwart Maui put his hands to it. In Celebes an earthquake is fabled to take place whenever Eber, who is supposed to be the earth-bearer, rubs himself against a tree and shakes his load. The world-bearing frog of the Mongol lamas, the world-ox of the Moslems, and the gigantic Omophore of the Manichæan cosmogony, are all creatures that carry the world on their back or head, and shake it whenever they stretch themselves or turn around. A similar part is performed in European mythologies by the Scandinavian Loki, who is bound with iron chains in his subterranean cave; by Prometheus, trying to break his chains; and by the Lettish Drebkuls. A branch of the Yuma Indians in Colorado are in dread of an evil spirit that is sleeping on Mount Avicome, and causes a slight earthquake when he moves uneasily, and a dangerous one when he turns clear over. The Caribs were accustomed to say, when there was an earthquake, that Mother Earth was dancing. The Iroquois, according to the testimony of many travelers, conceived the earth as an island in the sea, resting on the back of a huge tortoise. Floods occurred whenever the tortoise sank under the water, earthquakes when it shook itself or changed its position. The Hindoos imagined an earth-bearing elephant, standing on the tortoise, and attributed terrestrial convulsions to his motions. The Duphlas of Assam imagined four elephants supporting the four corners of the earth, which had to suffer when either of its bearers became uneasy.

According to the Kamchatkadales, earthquakes originate when the dogs of the earthquake-god, who travels in a sleigh under the ground, shake the fleas in the snow from themselves. The Siberian hunting

races perceive in the bones of the mammoth, so often found in their country, evidences of the real existence of underground monsters, whose movements may give rise to earthquakes. According to Livingstone, the natives of Magomoro relate that once when an earthquake occurred, by which rocks were thrown down from the mountains, the wise men of the country got together, and concluded that a star had fallen into the sea, and the consequent swelling of the waves had caused commotions over the whole earth.

Most of the astronomical conceptions of our Polynesian, African, and American brothers are childishly simple and crude enough, but at the same time curious. A very odd belief is that of the Namaqua Hottentots that the sun is a piece of bright bacon, which the people who go in ships draw up in the evening by enchantment, and let down again after they have cut a piece off from it. The Polynesians say that the god Maui holds the sun and regulates his course by means of a rope. In the beginning he hurt the star in catching it and deprived it of half its light, and since then the days have been longer and cooler, and men have been able to work in peace. The Japanese myths fable eight hundred thousand gods holding the sun with a rope, while it is all the time trying to get back into the cave out of which they have drawn it by means of a trick. The Society-Islanders have a story that the sun goes into the sea at night; it plunges in and is extinguished with a great hissing that can be heard away off in the west. And this recalls a story that is mentioned by Strabo. According to Bock, the Dyaks have a myth that the sun and the moon were made by the Almighty out of a peculiar clay which is found on the earth, but is very rare and costly, the vessels made from which, called *guji blanga*, are holy and protect against evil spirits. The settling of the sun's red disk upon the mountain-tops and its final descent behind the hills engaged the attention of dwellers in the regions where the phenomena assumed that character; and the Karens of Burmah and the mountain tribes of America spoke of the sun going down into a deep cleft in the rocks.

In passing over to the numerous myths in which the sun is regarded as a living being, we meet the belief of the Navajos that it is newly set in the sky every morning by a woman. Next, we come to a great number of stories that personify the sun, although they may not make a god of it, and represent its setting as a process of being swallowed by some monster. Sometimes it is a hero, sometimes it is a virgin, which is thus swallowed and afterward released or rejected, as in the Greek stories of Perseus and Andromeda and Hercules and Hesione, the old Norse story of Eireck and the Dragon, and the Teutonic myths of Little Red Riding-hood and the Wolf and of the Seven Little Goats.

Without going into the discussion of sun-worship, of which so much has been written, we may refer to the wide diffusion of the

practice in insular and continental Australasia, Northern Asia, and Central America.

Curious are the forms under which many people have figured the sun and moon. The simplest are the disk-forms, with or without rays, which are of frequent occurrence. On a temple of Palenque, while the sun has this form, the moon is represented as a shell-shaped vase or a spiral shell filled with water, out of which a hare is creeping. Squier found similar representations painted on the rocks in Nicaragua. In pictures ascribed to the Toltecs, the four great Mexican gods are bearing the eye-dotted sky on their shoulders and arms, while the sun-god and the moon-god are indicated under the symbols of the tiger and the hare—a form of representation that has extensively spread in North America. In the ancient Kami religion of the Japanese, the moon was worshiped as a fox. The Caffres and the Esquimaux ascribed an independent life to these planets, the latter people holding that they were human beings who had ascended to heaven, and conceiving the Moon to be the younger brother of the female Sun. In Peru the Moon-mother was both sister and wife of the Sun, like Osiris and Isis in Egypt. In the Lithuanian folk-songs the Moon takes the Sun to wife, and the Morning-Star is their daughter. The red Mintiras of the Malay Peninsula regard both Sun and Moon as women. In Southern Australia, among the Mbokobis in South America, and in the old Slavic sagas, the Moon is a man, and to the Khasias of Northwestern India he is the son-in-law of the Sun. By the Hurons the Moon is called the creator of the earth and grandmother of the Sun; in the myths of the Ottawas it is an old woman with a pleasant white face—the sister of the Day-Star. The Chiquitos call the Moon their mother, and the Navajos make it a rider on a mule. Where the planets are worshiped, preference in honors is generally accorded to the brighter and more conspicuous star of day. But the Botocudos of Brazil give the higher place to the Moon, and derive most of the phenomena of nature from it; and in Central America and Hayti are also people who hold the Moon in no less honor. Curiously, these people find their counterparts among tribes of Western, Southern, and Central Africa, who rejoice with dancing and feasts at each appearance of the new moon, and expect an improvement of their condition from its beneficent influence; and they are not so far removed from the superstitious women of civilized Europe and America who wait for the increase of the moon to change their dwelling, to cut their hair, to be married, and to baptize their children. A belief existed among the ancient Mexicans and Peruvians, the Natchez of the Mississippi, and the Appalachians of Florida, that the sun was the radiant abode of dead chiefs and braves. To the Esquimaux of Labrador belongs the honor of having discovered that the moon was the paradise for the good, while the wicked were consigned to a hole in the earth; although some of the South American Indians and the Poly-

nesians of Tokelau may be nearly abreast of them in the competition.

The facts we have adduced abundantly illustrate the various interest with which primitive peoples regard the two principal stars of the earthly sky. They have also their theories, or rather their myths, respecting the periodical changes to which the appearance of these bodies is subject. The phases of the moon are particularly the subject of much concern. In the belief of the Hottentots, the living being we call Moon suffers from a chronic headache, in consequence of which it becomes greatly reduced in appearance by laying its hand on its head. The Caffres bring the Sun into play in accounting for the phenomena, and say that she pursues the Moon and reduces him, but that he is cunning enough to escape, and then recovers his strength. More curious still is the part the waning moon plays in the eyes of some Polynesians, who say that it is eaten from by departed spirits. Another extremely materialistic explanation is found in some Greenland stories to the effect that the Moon pursues his sister the Sun in love. When he has become exhausted and thin, he goes seal-hunting, and disappears from the sky. In time he reappears, well fed, fat, and shining, as the full moon.

Purely fanciful and obscure are the myths in which animals are found in confidential relations with the moon. The Dakota Indians have a fiction of mice that periodically attack the moon to satisfy their hunger, and eat of its substance. An old Slavic saga makes the ruler of the night the husband of the Sun, who faithlessly gives his heart to the Morning-Star. In punishment for this offense, he is cleft through the middle, and must exhibit himself periodically in this plight as a warning example. The Hos, in Northeastern India, also fable the moon split in two and growing together again. In some of the stories these love-attacks become very violent, and then the aggressive party is made to receive a kind of retributive justice; and we accordingly have the spots that are to be seen upon the moon explained by saying that they are the marks which the vexed solar beauty has made upon her pursuer in defending herself against his importunities. Thus, according to Mr. D. Hooker, the Khasias in Northwestern India say that the Moon, an over-ardent son-in-law of the Sun, burns with love for her at each new change, while she, in her aversion, throws ashes into his face, which stick upon it as dark spots. The Esquimaux have two opposite, yet fundamentally harmonious, explanations. One is that the Sun smuts the face of her younger brother, whose attentions have become troublesome; the other, given by Bastian, that her heart warms toward her lover during his periods of darkness, and the spots are the marks left by her sooty hand caressing his face.

A variety of sagas of another kind discover living beings, not in the whole moon, but only in the dark points of its surface. The Hindoos fancy a hare in it, or a deer; the Japanese, a rabbit. According

to one of the Namaqua legends, the hare has scratched the moon, and the marks remain, but the animal itself has broken away, and is now continually fleeing before the planet. Who, in the face of such stories, can be oblivious of the general connection between the moon and the hunting goddess, and its personification in identity with her, which figure in the fables of classical antiquity?

A most remarkable fact is the agreement of peoples who have never had anything to do with one another—of South African tribes and the Northern Europeans, the Samoa-Islanders and the ancient Peruvians—in the belief that the spots in the moon represent a creature of our own species. The story of the man in the moon, which may be traced in Europe for some hundred years back, and appears in the old Norse myths, and which still charms our children, prevails in many different versions. The Raratongans recognize in it a departed chief; the Ossetes of the Caucasus, a demon, which they regard with an idolatrous fear; the Namaquas, a higher being, to whom they attach great importance; the Pottawattamie Indians, an old woman; the people of Timor, a spinster; the Mangaians, a busy housewife; and the ancient Peruvians, a courtesan. The Siamese see in it, now a hare, and now a married couple, who cultivate the fields and accumulate heaps of rice.

There remain to be considered the impressions that eclipses of the sun and moon make upon primitive peoples. A large number of their explanations represent the planets as a man and a woman, and sometimes bring in a child to help in producing the phenomena. The Jesuit Le Jeune was told by an Algonquin, in Canada, that the Sun and Moon were man and wife who had a child. When the father took up the little one to caress it, there was an eclipse of the sun; when the mother held it in her arms, an eclipse of the moon. According to the Mintiras of Malacca, the Sun and Moon are two women, of whom the former eats her children, while the Moon hides hers, although she is pledged to eat them too. Enraged at this breach of faith, the Sun chases the Moon around, swallowing her own star at each dawn, while the Moon brings hers out as soon as her pursuer is far enough away. At times, the enemies approach so nearly that the Sun can strike the Moon, and then there is an eclipse. The Hos of India have the same story, with the variation that the Moon, in punishment, is cut in two by the Sun, and has to grow together again. Notwithstanding the frequent recurrence of eclipses, with nothing particularly bad happening after them, most primitive peoples aasociate with them an omen of some great danger to the earth or the moon. The Greenlanders have a personal apprehension in the matter, and believe that the Moon rummages their houses for skins or victuals, and destroys those persons who have not observed due sobriety. The South American Chiquitos try to help the darkened star against a dog that has worried it till its light has been colored red, and extinguished by its streaming

blood; and they shoot arrows into the sky to drive away the dog. Charlevoix gives a similar account of the Guarani, except that with them a tiger takes the place of the dog; and in the language of the Tupis the literal translation of the word for an eclipse is, "The jaguar has eaten the sun." So, in Asia, the Tunguses believe an evil spirit has swallowed the earth's satellites, and they try to frighten it away by shots at the darkened disk. In Sumatra and Malacca the fear is aroused that a great snake will swallow the sun or the moon; and the Nagas of Assam set up a great drum-beating, as if in battle, to frighten away the devouring monster. Among the American tribes are some who believe that eclipses are a warning of the approaching disappearance of the sun and the fall of the moon at the end of the world. The Pottawattamies tell of a demon in the shape of an old woman, sitting in the moon weaving a basket, on the completion of which the world will be destroyed. A dog contends with the woman, tearing the basket to pieces every once in a while, and then an eclipse of the moon takes place; others imagine that the Moon is hungry, sick, or dying at these times; while the Alfuras of Ceram think he is asleep, and make a great uproar to awake him.

These superstitions are not so remote as they may seem at first sight from the impressions which the heavenly phenomena make upon many persons who consider themselves civilized. Circles may be found in nearly every nation upon whom the appearance of anything unusual in the sky carries an apprehension that something dreadful is about to happen; and by whom even the most ordinary phenomena are invested with occult influence upon things that we know have no connection with them; and it is only two or three centuries since the dire portents of comets and eclipses were prayed against in all the churches. In strange contrast with the impressiveness of the peoples whose names we have mentioned so often, and with the lingering European superstitions, stands the indifference of the stolid African tribes mentioned by Cameron and Paul Richard, who paid no attention to the eclipse, or thought it was only caused by passing clouds.—*Translated for the Popular Science Monthly from Das Ausland.*

SORGHUM AS A SOURCE OF SUGAR.

By HENRY B. PARSONS.

THE important part which sugar plays in our national and domestic affairs is, probably, not fully appreciated, except by those who have given the subject special study. Accustomed as we have become to hearing of the enormous output of our mines, it is at first somewhat difficult to realize that, in 1881, the people of the United States paid for foreign sugar, and imposts thereon, over fifty-seven

million dollars more than the value of all the gold and silver bullion produced in the same year.

In the year 1882 our imports of sugar and molasses amounted to nearly one and one fifth million tons, costing one hundred and fifty million dollars, nearly one third of which sum was paid as import taxes. There is no other article, or class of articles, upon which our Government levies duty which yields a revenue equal to that obtained from foreign sugar.

This useful staple furnishes nearly one fourth (24·3 per cent) of the amount received for import duties, and more than one seventh (14·6 per cent) of the total income of the nation.

That the demand for sugar is increasing much more rapidly than our population, is shown by the increased consumption per capita. The value of the sugar used in 1882 was fully one sixth greater than the amount in 1881. In 1790 to 1799 the average annual consumption of sugar per person was 9·65 pounds, while in 1882 the amount was not far from fifty-five pounds.

In order to obtain the sugar that we need, we find it necessary to buy of nearly every tropical and sub-tropical country. By far the greatest amount (forty per cent) comes from Cuba. Next in order are the Spanish possessions (three and a half per cent), Porto Rico (two and a half per cent), the Sandwich Islands and the Dutch East Indies (each one per cent), while twenty-seven other countries unite to furnish nearly forty per cent. It will be seen that there remains only about twelve per cent for home production. This is strictly true, for, to quote a recent authority, "From the statistics it appears that, during the past twenty years, the United States have produced less than thirteen per cent of their sugar-supply, and little more than twenty-one per cent of the molasses consumed."

If, therefore, our Cuban sugar-supply were suddenly arrested by insurrection or international complications, we might for a season be in an exceedingly embarrassing position. Possibly some other country would ultimately come to our relief; but it is very probable that, for a time, there would be a scarcity of sugar, which would result in unusually high prices. Such a condition of things would surely direct the thoughts of consumers and capitalists alike to our very inadequate provisions for the manufacture of sugar in Louisiana and adjacent Southern States, and the fact would be evident that we could not extend the domestic production of sugar from the cane to approximate our demands. The reason lies in the fact that the sugar-cane is essentially a tropical plant, and is seldom or never thoroughly ripened in our semi-tropical Southern States. Early frosts compel the planters to harvest the canes while yet considerably short of maturity, and consequently before the development of as large a percentage of sugar as is reached in warmer climates.

This climatic disadvantage is so serious as to confine the profitable

manufacture of sugar from the sugar-cane, in this country, to a very limited area, and to especially favorable seasons. This fact is emphasized and proved by reference to statistics which show that the amount of sugar produced in Louisiana in one year is frequently nearly twice as great as that obtained the next season.

Obviously, if it is desirable to produce our own sugar, the tropical sugar-cane can not be regarded as the chief source of supply, and we must place our dependence upon some plant better adapted to our varied soils and limited rainfall.

The sugar-beet has much to commend it; it is successfully raised in France, Germany, and Austria, and furnishes, at the present time, thirty per cent of the sugar consumed by civilized nations. But the sugar-beet requires special soil, special fertilizers, skillful cultivation, and, above all, an abundance of rain, which must come at just the right time to be of the greatest service. These conditions are well understood in Europe, and the tracts of country where beets may be profitably grown for sugar are known as "beet-sugar belts" upon the agricultural maps. Investigation has shown that the American beet-sugar belt is confined to a comparatively small portion of certain Northern and Middle States. It is possible that an important fraction of our sugar may yet be obtained from this source; but it is doubtful whether we should entertain hopes that this may ever be our chief dependence.

If, then, this country is to produce its own sugar, it is evident that some plant must be selected which, in one or more varieties, is adapted to our widely varied conditions. It must mature in the temperate Northern States as well as in the more genial climate of Southern California and the States bordering on the Gulf of Mexico. It must be easily cultivated—a plant of rapid growth, which, when mature, does not deteriorate until the season of severe frosts, thus insuring a long "working period," in which it may be converted into marketable sugar and molasses. Above all, it must furnish a juice rich in sugar, while containing a minimum of impurities.

It is claimed, by those who have given this sugar problem a very considerable amount of study, that in the better varieties of sorghum many or all of the above conditions are satisfied, and that, with intelligent culture and manufacturing methods, this country may not only produce all its own sugar, but may do its share toward supplying the ever-increasing demand abroad. These claims, if well supported, are deserving of careful study by all who desire to see the agricultural and manufacturing resources of this country more fully developed than at present.

The sorghum-plant (*Sorghum saccharatum*) belongs to the great family of grasses (*Graminaceæ*), and it may be termed a second-cousin to the tropical sugar-cane (*Saccharum officinarum*) on the one hand, and ordinary Indian corn (*Zea mays*) on the other. In some of its

varieties it looks not unlike broom-corn (*Sorghum vulgare*), to which it is also related.

There are many modifications, or so-called "sub-varieties," of sorghum, which differ greatly in height, size, weight, and general appearance. Some varieties mature in Minnesota in about one hundred days from planting (as the Early Amber), while other varieties are only ripened to perfection in the Southern States (as the Honduras). Although there are more than one hundred real or imaginary "sub-varieties" of sorghum within the limits of the United States, it is probably safe to say that the question of profitable sugar-production may be determined from experiments made with a few typical varieties, originally known as Chinese and African.

The first Chinese sorghum was imported into this country in 1853, from the noted house of Vilmorin, in France. In 1857 the African varieties, some sixteen in number, were brought to this country from Natal by an English merchant, named Leonard Wray. "To these African varieties the general name imphees was given, while to the variety from China the name Chinese sugar-cane was given." So-called hybrids have been extensively advertised, yet the weight of evidence is against hybridization of the different sorghums, and the new varieties are probably the products of mixed seed.

During the progress of the civil war, sorghum played no unimportant part in helping to supply a portion of the deficiency in our imports of sugar. In many of the Western States, notably Ohio and Illinois, great amounts of sorghum-molasses were made by the farmers with crude and inexpensive apparatus. Usually the sirup had a peculiar, sharp taste, due to imperfect purification of the juice, the use of lime for this purpose not being generally understood. As a rule, also, the canes were crushed while still unripe, and consequently not containing the maximum amount of sugar. In spite of these unfavorable conditions, the reports that sugar had crystallized from these sirups were not infrequent.

At the close of the war many who had made sorghum-sirup again preferred to buy foreign sugar and molasses. The introduction of glucose-sirups may also have been instrumental in diverting attention from sorghum, and, for ten or more years, comparatively little was heard of the new sugar-plant.

About the year 1876 it was again brought into public notice through very favorable results, obtained by farmers in the Northwestern States, in the production of sirup from the variety known as Minnesota Early Amber.

So many and frequent were the requests that this plant be investigated, that General William G. Le Duc, a Minnesota man, upon his accession to the office of Commissioner of Agriculture, in 1877, determined that the possibilities of this sugar-plant should be accurately ascertained for the benefit of all who were concerned.

Accordingly, in 1878, the work was commenced by Professor Peter Collier, Chemist of the Agricultural Department, at Washington, and his investigations were continued through the years 1879 to 1882, inclusive.

One of the principal objects of this work was the determination of the precise quality of sorghum-juices at different periods in the development of the plant, in order to show at what stage the greatest amount of available sugar was present in the juice. It was shown, by thousands of analyses, that fully-matured plants yielded the greatest amount of sugar, and that the period during which this amount was maintained was full three months for some of the varieties which matured most rapidly.

It was shown that some kinds of sorghum matured quickly, and were well adapted to the short, hot summer season of the Northern States, while other varieties ripened more slowly, and were best adapted for cultivation in the Southern States.

It was demonstrated also that, when mature, the best of the different varieties were practically identical as regards the percentage of available sugar in the juice.

The amount of crystallizable sugar in the juice of mature sorghum varies between fourteen and sixteen per cent; there are also present about one to two per cent of uncrystallizable sugar ("glucose"), and two to three per cent of other solids, part of which are removed from the juice by the purifying processes employed in sugar-making. When well purified, sorghum, cane, and beet sugar are identical in composition and properties.

Among other valuable data obtained during these investigations, were recorded the length of time, after seeding, before the plant reached maturity; the length of the period during which the juice contained a profitable amount of available sugar (i. e., the "working period"); the height, weight, and percentage of juice for the stalks of each variety of sorghum at each stage in its development; and numerous other facts of importance to the practical sugar-maker.

The utilization of waste, or by-products, was carefully considered. It was shown that sorghum-seed is very similar in composition and food-value to common Indian corn, and that the yield of twenty or more bushels per acre will nearly or quite repay the farmer the cost of cultivation. This seed has been successfully used for fattening cattle and swine.

It was shown that the apparently worthless skimmings obtained in the clarification of the juice had a value as fertilizing material, and that from the washings of the tanks and evaporators a considerable amount of pure alcohol or vinegar could be produced at small cost.

The crushed canes ("begasse"), after the removal of the juice, make paper-stock of excellent quality and medium length of fiber. This begasse may be preserved as food for cattle by the method known

as ensilage, or may be burned under the boilers, thus furnishing heat, and ashes valuable for fertilizing purposes.

But of greater value were the practical results obtained by Dr. Collier, with small and inexpensive apparatus, whereby he showed what could actually be done in the production of sugar and sirup from sorghum. These results were of more real importance than were the pretentious attempts made in Washington under the direction of a "practical sugar-boiler" from the West Indies, inasmuch as the latter experiments were made with improper and poorly-finished apparatus, and with sorghum not fully matured.

These experiments were also vitiated by the incompetence of the sugar-boiler, whose methods were those adapted to sugar-cane, and not varied to suit the different conditions presented when working with sorghum.

The smaller practical experiments conducted by Dr. Collier have been described in detail by himself, and, with perfect fairness, he has narrated not only successes but failures. All who are accustomed to manufacturing operations are aware that, notwithstanding the apparent simplicity of any new problem, the development of a practical working process involves a large amount of patient investigation, frequent experiments, and a not inconsiderable number of partial or seeming failures before complete success can be attained. But when such a process is thoroughly elaborated, and all its difficulties are appreciated and overcome, the details of manufacture may be safely intrusted to men of ordinary intelligence.

In November, 1881, the National Academy of Sciences appointed a special committee which was intrusted with a detailed investigation of the scientific processes, the analytical results, and the practical experiments and conclusions presented by Professor Collier.

All the members of this committee were men of the highest scientific ability, men whose reputation is world-wide, and whose conclusions must carry conviction. To quote from a recent number of "Science": "That the work has been well done is sufficiently guaranteed by the names of the committee. They were Professor William H. Brewer, Ph. D., of the Sheffield Scientific School; Professor Charles F. Chandler, of Columbia College; Professor S. W. Johnson, M. A., of the Sheffield Scientific School; Professor B. Silliman, M. A., M. D., of Yale College; Professor J. Lawrence Smith, M. D., late of the University of Louisville; and also, not of the Academy, Gideon E. Moore, Ph. D., of New York. Professor C. A. Goessmann, of the Massachusetts Agricultural College, was also a member of and acted with the committee until September 15, 1882, when he resigned."

The fairness and ability of the committee being unquestioned, it is germane, in this inquiry, to consider what their scrutiny of Dr. Collier's work has revealed as to the chances that sorghum may yet prove a valuable source of sugar. The following is taken from their report:

The spirit of scientific investigation which has led the Department of Agriculture through its chemical and agronomic researches to results of such importance toward developing a new industry of national value has been liberally fostered by the General Government, and to some extent also by certain of the States. The fruits of this policy are already beginning to show themselves in the decided success which has attended the production of sugar from sorghum on a commercial scale in the few cases in which the rules of good practice, evolved especially by the researches made at the laboratory of the Department of Agriculture, have been intelligently followed. Sufficiently full returns from the crop of 1882 have already come to hand to convince us that the industry is probably destined to be a commercial success.

The opinions of men so conservative as are the members of this committee can not be lightly set aside or ridiculed as visionary. That their predictions have, in a measure, been realized, will appear from the returns from the crop of 1883. From a recent work upon sorghum, by Professor Peter Collier, we extract the following:

Sorghum-Sugar produced in 1883.

According to the statement of the President of the Mississippi Valley Cane-Growers' Association, there were produced at the Champaign (Illinois) Sorghum-Sugar Works, from 145 acres, 1,435 tons of cane; and from 2,400 tons of cane there were obtained 160,000 pounds of sugar and 40,000 gallons of molasses.

The season is described as being the most unfavorable for thirty years.

At Hutchinson, Kansas, some 200,000 pounds of sugar, besides a large quantity of molasses.

At Sterling, Kansas, some 200,000 pounds of sugar, besides the molasses.

At Dundee, Kansas, 10,000 pounds of sugar, though their product was mainly sirup, of which 50,000 gallons were made.

At Kinsley, Kansas, 10,000 pounds of sugar, and a large quantity of sirup.

At Lawrence, Kansas, some 10,000 pounds of sugar.

At Rio Grande, New Jersey, 282,711 pounds of sugar and 55,000 gallons of molasses—a large portion of their cane failing to ripen, owing to the unusual season.

The Secretary of the Kansas State Board of Agriculture reports the following summary of the year 1883 for Kansas:

Acres planted in sorghum	102,042
Acres manufactured into sirup	48,271
Acres planted for forage	53,771
Tons of cane manufactured	447,859
Gallons of sirup made	4,684,023
Value of sirup made	$2,058,127 60

The entire number of counties reporting was eighty-one, and of these—

32	grew from	50 to	500	acres.
20	"	500 to	1,000	"
10	"	1,000 to	2,000	"
10	"	2,000 to	3,000	"
5	"	3,000 to	4,000	"
4	"	4,000 to	8,000	"

Ten counties produced over 100,000 gallons of sirup each, and two counties produced over $100,000 worth of sirup each, while seventeen counties produced each over $30,000 worth of sirup.

The value of sirup averaged from each acre $42.65, without counting the product of seed. The yield averaged 9·3 tons of cane per acre.

For the first years of a new industry such returns can not be considered other than decidedly promising. That the probabilities are strongly in favor of the ultimate success of sorghum as a source of sugar can hardly be doubted; but that the growth of such a vast industry must be gradual, and may at times be checked by the failures of untrained experimenters, is to be expected. It should be borne in mind, however, that one successful trial, resulting in the production of sugar in paying amounts, is of more value in estimating the possibilities of this new industry than are many failures. The development of any great industry is necessarily slow; especially is this true when manufacturers are not guided by previous experience with closely-related crude materials. The perfection of the manufacturing processes for beet-sugar is an illustration of this point.

It may be interesting, in this connection, to trace briefly the history of beet-sugar in France.

In 1747 Margraff presented a memoir to the Berlin Academy of Sciences, describing the methods whereby he had prepared sugar from beets, and urging the importance of his discovery. Little came of this investigation until half a century had elapsed, when Karl Franz Achard, a former pupil of Margraff, again drew attention to the matter. In 1799 he read a paper before the Institute of France, in which he described his methods and results. He exhibited samples of beet-sugar, and made such an impression that the French Institute appointed a commission, consisting of eminent men of science, to repeat Achard's work. They found about six per cent of sugar in beets, and thought that refined sugar could be produced for about eighteen cents per pound, or for less, if improved manufacturing methods were adopted.

MM. Barruel and Isnard were the first to produce beet-sugar on the commercial scale; they obtained only one and a half per cent of inferior sugar, at a cost of thirty cents per pound.

In 1811 M. Drappiez, of Lille, made beet-sugar at a cost of eighty cents a pound. Even this result, which would seem a disastrous failure to most observers, was sufficiently encouraging to justify the famous decree of Napoleon "that 32,000 hectares (79,040 acres) shall be planted in beets; that six experimental schools to give instruction in the manufacture of beet-sugar shall be established, and that 1,000,000 francs [$200,000] shall be appropriated from the budgets for this purpose, and for the experiments in producing indigo." "The importation of sugar and indigo from England and her colonies was prohibited."

With the aid of this liberal appropriation, and of numerous substantial gratuities to individuals, the development of this industry was still slow. In 1826 only 1,500 tons of beet-sugar were produced in France, but after that time the increase was more rapid, and we find France producing 420,396 tons of beet-sugar in 1879.

From small and inauspicious beginnings the beet-sugar industry has slowly grown, until it is securely established in France, Belgium, Austria, and Germany. At present, three eighths of the sugar used by civilized nations is produced by the sugar-beet. In like manner, the production of sugar from sorghum may not attain great proportions until some years have passed, but the plant is richer in sugar and is much more easily cultivated and handled than is the sugar-beet. The production of sorghum-sugar at a profit is less problematical than was the successful manufacture of beet-sugar when Napoleon issued the decree which laid the foundations of the beet-sugar industry in France.

The results of recent investigations of sorghum in the hands of other experimenters, as well as the immense amount of work done at Washington, have been rendered available, for the general reader and those interested in scientific and practical details, by a recent book written by Dr. Collier.* In this work, of over five hundred pages, a great number of scientific and economic problems are discussed, and our present definite knowledge of various points, formerly disputed, is clearly stated. The chemical changes occurring in the plant during its development have been recorded with an exactness suited to delight the student of vegetable physiology, while the practical sugar-maker need not look in vain for the latest information as to machinery and manufacturing processes. Farmers wishing to grow sorghum are told what varieties are most likely to succeed in Northern and what other varieties in Southern latitudes, and the best methods of planting, fertilizing, and securing the crop are carefully described.

In fact, this work has been well done, and its completeness is creditable alike to the thoroughness and the ability of the author. It is fortunate for this industry and for the country that these investigations have been prosecuted by a chemist so competent, and it is to be hoped that Congress may see fit to continue this work under the direction of Dr. Collier.

In view of the fact that the special committee of the National Academy has reported as its opinion, based on facts thus far presented, that the production of sugar from sorghum is likely to prove a commercial success, this country can well afford to expend liberal amounts of money for a continuation of these investigations, and for a practical demonstration of the cost of manufacturing sugar on the large scale.

* "Sorghum: Its Cultivation and Manufacture economically considered as a Source of Sugar, Sirup, and Fodder." By Peter Collier, Ph. D., late Chemist of the United States Department of Agriculture, Washington, D. C. Cincinnati: Robert Clarke & Co.

If, as a result of several seasons' practical operations, it shall be clearly shown that sugar can be profitably made from sorghum, an industry will speedily be established which will furnish employment for much labor and capital, and will add large sums to the wealth of this nation.

THE CHEMISTRY OF COOKERY.

By W. MATTIEU WILLIAMS.

XXXIV.

RESPECTING the *rationale* of the change that takes place in reheating stale bread, thereby renewing it and making it appear moist by actually driving away some of its moisture, the results of my investigations are as follow:

I find that, as bread becomes stale, its porosity *appears* to increase, and that, when renewed by reheating, it returns to its original *apparently* smaller degree of porosity. That this change can be only apparent is evident from the facts that the total quantity of solid material in the loaf remains the same, and its total dimensions are retained more or less completely by the rigidity of the crust. I say "more or less," because this depends upon the thickness and hardness of the crust, and also upon the completeness of its surrounding. Lightly-baked loaves shrink a little in dimensions in becoming stale, and partly regain the loss on reheating, but this difference only exaggerates the apparent paradox of varying porosity, as the diminished bulk of a given quantity of material displays increased porosity, and the increase of total dimensions accompanies the diminished porosity.

A reconciliation of this paradox may be obtained by careful examination of the structure of the crumb. This will show that the larger or decidedly visible pores are cells having walls of somewhat silky appearance. This silky luster and structure is, I have no doubt, due to a varnish of dextrin, the gummy nature of which I have already described. Now look a little more closely at this inner surface of the big blow-holes with the aid of a hand-lens of moderate power. It is not a continuous varnish of gum, but a net-work or agglomeration of gummy fibers and particles, barely touching each other.

My theory of the change that takes place as the bread becomes stale is that these fibers and particles gradually approach each other either by shrinkage or adhesive attraction, and thus consolidate and harden the walls of each of the millions of visible pores, i. e., the solid material of which the loaf is made up. In doing so they naturally increase the dimensions of these visible pores, while the invisible interstices or spaces between the minute fibers of the cell-walls are diminished by the approximation or adhesion of these fibers to each other.

This adhesion is probably aided by an oozing out or efflorescence of the vapor held by the fibers, and its condensation on their surfaces. This point, be it understood, is merely hypothetical, as the efflorescence is not visible.

When the stale bread is again heated, a general expansion occurs by the conversion of liquid water into aqueous vapor, every grain of water thus converted expanding to seventeen hundred times its former bulk. As this happens throughout, i. e., upon the surface of every one of the countless fibers or particles, there must be a general elbowing in the crowd, breaking up the recent adhesion between these fibers and drawing them all apart in the directions of least resistance, i. e., toward the open spaces of the larger and visible pores, producing that *apparent* diminution of porosity that I have observed as the visible characteristic of the change.

This explanation of the change may be further demonstrated by cutting a loaf through the middle from top to bottom, and exposing the cut surfaces. In this case the bread becomes unequally stale, more so near the cut surface than within. The unequal pull due to the greater adhesive approximation of the fibers and small particles causes a rupture of the exposed surface of the crumb, which becomes cracked or fissured without any perceptible alteration of the size of the visible pores. If the two broken faces be now accurately placed together, the halves thus closely joined, firmly tied together, and placed for an hour in the oven, it will be seen on separating them that the chasms are considerably closed, though not quite healed. Careful examination of the structure of the inside, by breaking out a portion of the crumb, will reveal that loosening of the structure which I have described.

I should add that, in quoting the figures given by Boussingault in my last, I inadvertently omitted to reduce them from the French to the English thermometric scale: 130° to 150° centigrade is equal to 266° to 302° Fahr., which is considerably below the temperature required for starting the original baking.

"Popped corn" is a peculiar example of starch-cookery. Here a certain degree of porosity is given to an originally close-compacted structure of starch by the simple operation of explosive violence due to the sudden conversion into vapor of the water naturally associated with the starch. The operation is too rapid for the production of much dextrin.

As most of my readers doubtless know, peas, beans, lentils, and other seeds of leguminous plants are more nutritious, theoretically, than the seeds of grasses, such as wheat, barley, oats, maize, etc. I was glad to see at the Health Exhibition a fine series of the South Kensington cases displaying in the simplest and most demonstrative manner the proximate analyses of the chief materials of animal and vegetable food. I refer to them now because they do not receive the attention they deserve. On the opening day there was, out of all the

crowd, only one other besides myself bestowing any attention upon them. I soon learned in conversation with him that he is a reader of "Knowledge." These cases show one pound of wheat, oats, potatoes, peas, etc., etc., on trays; by the side of these are bottles, containing the quantity of water in the one pound, and other trays, with the other constituents of the same quantity, the starch, gluten, casein, the mineral matter, etc., thus displaying at a glance the nutritive value of each so far as chemical analysis can display it. Those Irishmen and others, who think I have been too hard upon the potato, will do well to take its nutritive measure thus, and compare it with that of other vegetable foods.

They will see that all the leguminous seeds, the ground-nuts, etc., have their nitrogenous constituents displayed under the name of "casein." The use of this term is rather confusing. In many modern books it does not appear at all in connection with the vegetable kingdom, but is replaced by "legumin." Liebig regarded this nitrogenous constituent of the leguminous seeds, almonds, etc., as identical with the casein of milk, and it was a pupil and friend of Liebig's—the late prince consort—who devised and originally supervised this graphic method of displaying the chemistry of food.*

I will not here discuss the vexed question of whether the analyses of Liebig, identifying legumin with casein, or rather those of Dumas and Cahours, who state that the vegetable casein is not of the same composition as animal casein, are correct.

The following figures display my justification for thus lightly treating the discussion:

	Casein.	Legumin.	Legumin.	Legumin.
Carbon	53·7	50·50	55·05	56·24
Hydrogen	7·2	6·78	7·59	7·97
Nitrogen	16·6	18·17	15·89	15·83
Oxygen } Sulphur }	22·5	24·55	21·47	19·96

The first column shows the results of Dumas for animal casein; the second those of Dumas and Cahours for legumin; the third those of Jones for the same; and the fourth those of Rochleder; all as quoted by Lehmann. Here it will be seen that the differences upon which Dumas and Cahours base their supposed refutation of the identity of the animal with the vegetable principle are much smaller than the differences betwen the results of different analyses of the latter. These

* Shortly after the close of the Great Exhibition of 1851, when the South Kensington Museum was only in embryo, I had occasion to call at the "boilers," and there found the prince hard at work giving instructions for the arrangement and labeling of these analyzed food-products and the similarly displayed materials of industry, such as whalebone, ivory, etc. I then, by inquiry, learned how much time and labor he was devoting, not only to the general business of the collection, but also to its minor details.

differences, I suspect, are all due to the difficulty of isolating the substances in question, especially of the vegetable substance, which is so intimately mixed with the starch, etc., in its natural condition that complete separation is of questionable possibility.

This will be understood by the following description of the method of separation as given by Miller ("Elements of Chemistry," Vol. III): "Legumin is usually extracted from peas or from almonds, by digesting the pulp of the crushed seeds in warm water for two or three hours. The undissolved portion is strained off by means of linen, and the turbid liquid allowed to deposit the starch which it holds in suspension; it is then filtered and mixed with dilute acetic acid. A white flocculent precipitate is thus formed, which must be collected on a filter and washed."

This is but a mechanical process, and its liability to variation in result will be learned by anybody who will repeat it, or who has separated the gluten of flour by similar treatment.

Practically regarded in relation to our present subject, casein and legumin may be considered as the same. Their nutritive values are equal and exceptionally high, supposing they can be digested and assimilated. One is the most difficult of digestion of all the nutritive constituents of vegetable food, and the other enjoys the same distinction among those of animal food. Both primarily exist in a soluble form; both are rendered solid and insoluble in water by the action of acids; *both are precipitated as a curd by rennet*, and both are rendered soluble after precipitation or are retained in their original soluble form by the action of alkalies. They nearly resemble *in flavor*, and John Chinaman makes actual cheese from peas and beans.

These facts, coupled with what I have already said concerning cheese and its cookery, will doubtless lead my readers to expect something concerning pease-pudding and potash in my next.

XXXV.

"Pease-pudding hot, pease-pudding cold,
Pease-pudding in the pot, nine days old."

I leave to Mr. Clodd the historical problem of determining whether this notable couplet is of Semitic, Aryan, Neolithic, or Palæolithic origin. Regarded from my point of view it expresses a culinary and chemical principle of some importance, and indicates an ancient practice that is worthy of revival.

I have lately made some experiments on the ensilage of human food, whereby the cellular tissue of the vegetable may be gradually subjected to that breaking up of fiber described in No. 28. One of the curious achievements of chemical metamorphoses that is often quoted as a matter for wonderment is that of converting old rags into sugar by treating them with acid. The wonderment of this is diminished, and its interest increased, when we remember that the cellulose

or woody fiber of which the rags are composed has the same composition as starch, and thus its conversion into sugar corresponds to the every-day proceedings described in No. 30. All that I have read and seen in connection with the recent ensilage experiments on cattle-fodder indicates that it is a process of slow vegetable cookery, a digesting or maceration of fibrous vegetables in their own juices which loosens the fiber, renders it softer and more digestible, and not only does this, but, to some extent, converts it into dextrin and sugar.

I hereby recommend those gentlemen who have ensilage-pits and are sufficiently enterprising to try bold experiments, to water the fodder, as it is being packed down, with dilute hydrochloric acid or acetic acid, which, if I am not deluded by plausible theory, will materially increase the sugar-forming action of the ensilage. The acid, if not over-supplied, will find ammonia and other bases with which to neutralize itself.

Such ensilage will correspond to that which occurs when we gather Jersey or other superlatively fine pears in autumn as soon as they are full grown. They are then hard, woody, and acid, quite unfit for food, but by simply storing them for a month, or two, or three, they become lusciously soft and sweet, the woody fibers are converted into sugar, the acid neutralized, and all this by simply fulfilling the conditions of ensilage, viz., close packing of the fiber, exclusion of air by the thick rind of the fruit, *plus* the other condition which I have just suggested, viz., the diffusion of acid among the well-packed fibers of the ensilage material.

In my experiments on the ensilage of human food I have encountered the same difficulty as that which has troubled graziers in their experiments, viz., that small-scale results do not fairly represent those obtained with large quantities. There is, besides this, another element of imperfection in my experiments respecting which I am bound to be candid to my readers, viz., that the idea of thus extending the principle was suggested in the course of writing this series, and, therefore, a sufficient time has not yet elapsed to enable me (with much other occupation) to do practical justice to the investigation.

I find that oatmeal-porridge is greatly improved by being made some days before it is required, then stored in a closed jar, brought forth and heated for use. The change effected is just that which theoretically may be expected, viz., a softening of the fibrous material, and a sweetening due to the formation of sugar. This sweetening I observed many years ago in some gruel that was partly eaten one night and left standing until next morning, when I thought it tasted sweeter, but, to be assured of this, I had it warmed again two nights afterward, so that it might be tasted under the same conditions of temperature, palate, etc., as at first. The sweetness was still more distinct, but the experiment was carried no further.

I have lately learned that my ensilage notion is not absolutely new.

A friend who read my Cantor lectures tells me that he has long been accustomed to have seven dishes of porridge in his larder, corresponding to the days of the week, so that next Monday's breakfast was cooked the Monday before, and so on, each being warmed again on the day fixed for its final execution, and each being thus seven days old. He finds the result more digestible than newly-made porridge. The classical nine days' old pease-pudding is a similar anticipation, and I find, rather curiously, that nine days is about the limit to which it may be practically kept before mildew—moldiness—is sufficiently established to spoil the pudding. I have not yet tried a barrel full of pease-pudding or moistened pease-meal, closely covered and powerfully pressed down, but hope to do so.

Besides these we have a notable example of ensilage in sour-kraut—a foreign luxury that John Bull, with his usual blindness, denounces, as a matter of course. "Horrid stuff," "beastly mess," and such-like expressions, I hear whenever I name it to certain persons. Who are these persons? Simply Englishmen and Englishwomen who have never seen, never tasted, and know nothing whatever of what they denounce so violently, in spite of the fact that it is a staple article of food among millions of highly-intelligent people. Common sense (to say nothing of that highest result of true scientific training, the faculty of suspending judgment until the arrival of knowledge) should suggest that some degree of investigation should precede the denunciation.

In the cases of the sour-kraut and the ripening pear there is acid at work upon the fiber, which, as I have before stated, assists in the conversion of such indigestible fiber into soluble and digestible dextrin and sugar; but the demand for the solution of the vegetable casein or legumin, which has such high nutritive value and is so abundant in peas, etc., is of the opposite kind. Acids solidify and harden casein, alkalies soften and dissolve it. Therefore the chemical agent suggested as a suitable aid in the ensilage or slow cookery, or the boiling or rapid cookery, of leguminous food is such an alkali as may be wholesome and compatible with the demands for nutrition.

Now, the analyses of peas, beans, and lentils, etc., show a deficiency of potash salts as compared with the quantity of nitrogenous nutriment they contain; therefore I propose, as in the case of cheese-food, that we should add this potash in the convenient and safe form of bicarbonate, not merely add it to the water in which the vegetables may be boiled, and which water is thrown away (as in the common practice of adding soda when boiling greens), but add the potash to the actual pease-porridge, pease-pudding, lentil-soup, etc., and treat it as a part of the food as well as an adjunct to the cookery. This is especially required when we use dried peas, dried beans of any kind, such as haricots, dried lentils, etc.

I find that taking the ordinary yellow split-peas and boiling them

in a weak solution of bicarbonate of potash for two or three hours, a partial solution of the casein is effected, producing pease-pudding, or pease-porridge, or *purée* (according to the quantity of water used), which is softer and more gelid than that which is obtained by similarly boiling without the potash. The undissolved portion evidently consists of the fibrous tissue of the peas, the gelatinous or dissolved portion being the starch, with more or less of casein. I say "more or less," because, at present, I have not been able to determine whether or not the casein is all rendered soluble. The flavor of the clear pea-soup, which I obtained by filtering through flannel, shows that some of the casein is dissolved; this is further demonstrated by adding an acid to the clear solution, which at once precipitates the dissolved casein. The filtered pea-soup sets to a stiff jelly on cooling, and promises to be a special food of some value, but, for the reasons above stated, I am not yet able to speak positively as to its practical value. The experience of any one person is not sufficient for this, the question being, not whether it contains nutritive material—this is unquestionable—but whether it is easily digested and assimilated. As we all know, a food of this kind may "agree" with some persons and not with others—i. e., it may be digested and assimilated with ease or with difficulty according to personal idiosyncrasies. The cheesy character of the abundant precipitate, which I obtain by acidulating this solution, is very interesting and instructive, regarded from a chemical point of view. The solubility of the casein is increased by soaking the peas for some hours, or, better still, a few days, in the solution of bicarbonate of potash.

Another question is opened by these experiments, viz.: What is the character and the value of the fibrous solid matter remaining behind after filtering out the clear pea-soup? Has the alkali acted in an opposite manner to the acid in the ripening pear? Is it merely a fibrous refuse only fit for pig-food, or is it deserving of further attention in the kitchen? Should it be treated with dilute acid—say a little vinegar—to break up the fiber, and thereby be made into good porridge? Other questions crop up here, as they have been cropping continually since I committed myself to the writing of these papers, and so abundantly that, if I could afford to set up a special laboratory, and endow it with a staff of assistants, there would be some years' work for myself and staff before I could answer them exhaustively, and doubtless the answers would suggest new questions, and so on *ad infinitum*. I state this in apology for the merely suggestive crudity of many of the ideas that I throw out in the course of these papers.

Before leaving the subject of peas, I must here repeat a practical suggestion that I published in "The Birmingham Journal" about twenty years ago, viz., that the water in which green peas are boiled should not be thrown away. It contains much of the saline constitu-

ents of the peas, some soluble casein, and has a fine flavor, the very essence of the peas. If to this, as it comes from the saucepan, be added a little stock, or some Liebig's extract, a delicious soup is at once produced, requiring nothing more than ordinary seasoning. With care, it may form a clear soup such as just now is in fashion among the fastidious; but, prepared however roughly, it is a very economical, wholesome, and appetizing soup, and costs a minimum of trouble.

I must here add a few words in advocacy of the further adoption in this country of the French practice of using, as *potage*, the water in which vegetables generally (excepting potatoes) have been boiled. When we boil cabbages, turnips, carrots, etc., we dissolve out of them a very large proportion of their saline constituents—salts which are absolutely necessary for the maintenance of health; salts, without which we become victims of gout, rheumatism, lumbago, neuralgia, gravel, and all the ills that human flesh, with a lithic-acid diathesis, is heir to, i. e., about the most painful series of all its inheritances. The potash of these salts existing therein, in combination with organic acids, is separated from these acids by organic combustion, and is then and there presented to the baneful lithic acid of the blood and tissues, the stony torture-particles of which it converts into soluble lithate of potash, and thus enables them to be carried out of the system.

I know not which of the fathers of the Church invented fast-days and *soup maigre*, but could almost suppose that he was a scientific monk, a profound alchemist, like Basil Valentine, who, in his seekings for the *aurum potabile*, the elixir of life, had learned the beneficent action of organic potash salts on the blood, and therefore used the authority of the Church to enforce their frequent use among the faithful.—*Knowledge.*

HYGIENE FOR SMOKERS.

By Dr. FÉLIX BREMONT.

THIS article is not intended for school-boys desiring to enjoy their cigarettes out of the sight of their tutor, nor for children who try to play the man by taking up one of his faults. It is addressed to smokers, but does not purpose to increase the number of them. Its design is to indicate what precautions may be taken to diminish as far as possible the inconveniences of smokers' glandular irritation; but it affirms the reality of these inconveniences, and declares it impossible to remove them completely.

The first hygienic principle relative to tobacco is, then, Do not smoke at all; don't smoke at any age. More than one old smoker will agree

with me that it would have been good for him if he had never lit a cigar; for he suffers now if he can not smoke a half-dozen of them in the course of the day. The habit of smoking creates a factitious want that is, perhaps, more imperative than real wants, and which is a constant trouble to those who feel it. When I have a pressing engagement after dinner, I cut my meal short so as to have time to smoke a cigar; and there is to me nothing to suggest doubt in the story related by Philibert Audebrand of Father Schoëne, director of Louis Philippe's park of Monceaux, who loved two things—his plants and his pipe. From morning till night he lived in the garden, and from morning till night he carried a short pipe in his mouth, which he would not take out for any one. "It may pass before me," said Louis Philippe to him one day "but to smoke so in the presence of the queen and the princesses!" "Sire," replied Schoëne, "it is stronger than I am. If your majesty is not satisfied with my service, I shall have to present my account; I shall probably die with vexation over the matter, but it will be with my pipe between my teeth."

Do not enroll yourselves, then, beardless readers, in the battalions of Nicotia. Initiation into her mysteries has painful accompaniments, and her fervent worship brings troubles of another character. Tobacco is smoked in cigars, cigarettes, and pipes. Placed in contact with the mouth, the cigar, which can not escape some chewing, colors the saliva and charges it with the toxic principles of the tobacco—elements, principally nicotine, that should be carefully rejected. A person smoking only a simple light cigar may, perhaps, see the end of it without spitting, but, if he consumes any number of them, he must spit frequently. This exercise is less indispensable when a cigar-holder is used, and the adoption of such a mouth-piece is recommended by hygiene as a means of avoiding the direct contact of the mouth with the tobacco, and considerably diminishing the inconveniences of smoking. Cigar-holders are made of amber, shell, glass, bone, cherry, birch, lilac, jasmin, maple, and cane. Holders made from the last wood are the best, because they are generally longer than the others, whereby the smoke may become cooled, and because, being very cheap, they can be frequently renewed. Other inconveniences, involving questions of cleanliness, are avoided by the use of the cigar-holder. Too many hands touch the tobacco while it is being manufactured into a cigar for one to be able to say it has not been soiled, and cases of its having been the vehicle for conveying contagious disease are not unknown.

Havana cigars are the best, but how to get them? The coat does not make the monk, nor does the label make a real Havana. We read in the "Journal d'Hygiène" that cigars are bought at very cheap prices at various places in Europe, and then shipped to Havana, where they are boxed and labeled and sent back to Europe. According to M. Cardon, the matter is arranged more expeditiously at Hamburg and

Frankfort, where cabbage-leaf cigars are sold as real Havanas under the government stamp, which they have acquired the right to bear by being sent out to meet vessels coming in from Cuba, whose arrival in the Baltic or in the Channel has been signalized. The cigars go through the custom-house, get the government mark, and are worth ten times as much as they were before their little excursion. It is a good hygienic precaution to choose dry cigars. The nicotine, being volatile, gradually escapes during the drying process, and the smoker consequently absorbs less of it. The absorption is also less when the smoking is done slowly; but, if one smokes fresh cigars fast and without spitting, his mouth and nervous system become so saturated with the narcotic ingredients of the smoke that, according to Professor Johnston, every kind of pipe becomes insipid to him.

Tobacco rolled up in a thin, combustible substance, which is burned with it, forms a cigarette. Many doctors regard this as the most dangerous form in which tobacco can be smoked. Dr. Barré recently invited smokers of cigarettes, in the journal "Le Peuple Français," to observe if they did not, after having smoked ten or a dozen of them, feel a pressure on the left side, with palpitation of the heart. The more we advance in the practice of medicine, he added, and the more we question our fellow-doctors, "the more we are convinced that the abuse of the cigarette is one of the most frequent causes of diseases of the heart." As for myself, I have never observed the troubles noticed by Dr. Barré; but I have remarked others, particularly inflammatory angina and laryngitis. The irritation of the back part of the mouth and respiratory channels probably arises from the habit, common with smokers, of swallowing the smoke. This is a noxious practice, and must be avoided. In some countries cigarettes are rolled in corn or plantain leaves; in France, we roll them in paper. A great many persons think that the mischievous effects of the cigarette are due to this envelope. I owe it to the truth to say that the accusation has not been established. If the use of the cigarette is really more injurious than that of the cigar, it is probably because, in cigarette-smoking, we have to use tobacco that is more moist, and consequently more charged with nicotine. The question respecting the envelope is not yet solved. The makers of cigarette-paper certainly take great care to fill the public with the idea of danger attending the use of paper of bad quality. They all offer the smoker superior papers, of pure fiber. The more refined offer coal-tar paper, to prevent chest-irritation; ferruginous paper, as a guard against anæmia; and even pepsin-paper, to facilitate digestion. It is all smoked, and that is the end of it. Use any paper you please, gentlemen; the important thing for hygiene is, that you do not use too much. The same recommendation is addressed to the ladies—for there are ladies who smoke; the Society of Public Medicine was occupied with them in 1880. MM. Decaisne, Delaunay, Thévenot, Bouley, Brouardel, and Goyard said some very interesting things on the occasion; but,

after a brilliant oratorical display, "richer in arguments than in observed facts," the society wisely concluded that "it was not necessary to conclude anything." That is my position on this vexed question of cigarette-paper.

Larouse says that, although it is admitted as a principle that only the cigar is in good taste in the street, the pipe is, in the privacy of home, the relaxation of persons in the highest social classes as well as of the masses. The observation is just. All great smokers use the pipe. The poor smoke a modest clay pipe; the rich a meerschaum set with silver and amber, carved and engraved like a precious stone; poor and rich, consuming much tobacco, burn it in an incombustible bowl with a tube attached; whatever it may be, it is still a pipe, and, if it costs more, it is no better than the cheaper one, but rather the contrary. If all pipes were equally durable, they might be classed, according to their merit, as follows: 1. Soft earthen pipe; 2. Meerschaum; 3. Hard earthen pipe, white or colored; 4. Wooden pipe; 5. Porcelain pipe; 6. Metallic pipe.

The white earthen pipe, porous and permeable to liquids, is put first, because it is a good absorber of nicotine; the metallic pipe is put last, because it allows all the noxious products formed during the combustion of the tobacco to reach the mouth of the smoker. The meerschaum, which immediately follows the clay pipe, deserves its place only on condition that it is not too old. If it is seasoned, it is as bad as a wooden or porcelain pipe. The seasoning, of which poets have sung, may be full of charms for the amateur; to the hygienist, it simply indicates that the pipe has had its day, and is now saturated with tobacco-juice; and that it must be replaced by another one, or be passed through the fire to purify it, as is done in the coffee-houses of Holland. Every old pipe, browned with long use, leaves on the lips and tongue an acrid and strong-smelling liquid which irritates the tissues and corrodes the mucous secretions. When it has reached this condition, the finest meerschaum is no better than the meanest scorch-throat. Independently of the substance, the form of the pipe has an influence on the proportion of noxious ingredients which tobacco-smoke contains. Turkish and Indian pipes, in which tobacco is burned slowly, discharging its smoke through a liquid, arrest a large proportion of the poisonous ingredients. The bowl of the German pipe retains the greater part of the oily products; the Dutch and English clay pipes retain less. The metallic pipes of Thibet, becoming heated, carry to the mouth not only brown liquids saturated with nicotine, but also a smoke hot enough to burn the tongue. The pipe should, then, be long, and, in order that the smoker may become convinced of this, I submit to him these lines by Dr. Buisson, taken from his article on "The Lips," in the "Dictionnaire Encyclopédique des Sciences Médicales": "It is not without reason that the popular tongue has energetically described by the name *brûle-gueule* (scorch-throat) the pipe with a short stem.

Not only is this stem impregnated with the empyreumatic matter with which old pipes become browned in seasoning, but it is heated to such a degree as to subject the lips to a local elevation of temperature, a kind of chronic burning, which causes a thickening of the epithelial layer in the same manner as the contact with hot bodies increases the epidermic secretion on the hands of subjects exercising certain professions." It should be added that every smoker should have his own pipe, and not use indifferently any one that comes to hand.

Whether we smoke a cigar, a cigarette, or a pipe, two hygienic precepts should not be lost sight of: The first relates to the atmosphere, and may be formulated—it is less injurious to smoke in the open air than in a room, in a large room than in a small one. Be careful, then, smokers, to ventilate liberally and frequently the apartments in which you smoke your tobacco. The second precept is a question of cleanliness. If it is good for every one to attend frequently to the washing of his mouth and teeth, the usefulness of the habit becomes a rigorous obligation to every one who is addicted to the pipe, the cigar, or the cigarette. A wet cloth passed over the gums and teeth in the morning may possibly be enough for persons who do not smoke, but the brush is indispensable for smokers. A simple gargle of aromatized warm water is better to neutralize the odor of tobacco than the best scented pellet.—*Translated for the Popular Science Monthly from the Journal d'Hygiène.*

HOW THE DODDER BECAME A PARASITE.

By JOSEPH F. JAMES.

OVER yonder in the corner of a field there grows a mass of yellow threads, looking at a distance like an immense spider's web covering a number of plants. Closer inspection reveals it to be the dodder, poetically called by some the golden-thread. Though beautiful in the abstract, handsome in its golden color, it is yet a vile and pernicious weed—one that in the flax-fields of Europe in one form, and in the alfalfa-fields of California in another, has done a vast deal of harm. Yet it is, to look at, beautiful. The flexuous stem of golden yellow, adorned with clusters of white, bell-shaped flowers, twining among and over other plants, forms a striking contrast with their green stems and leaves. And it is no wonder it has been sometimes cultivated for its beauty. Why, then, should we call it a pernicious weed? Look closer, and you will see that at intervals along the stem, where it clings closely to other plants, it has sent out bunches of little rootlets, which, not content with performing the office of hold-fasts,

force their way through the bark, penetrate the tissue, and take the matter found there into their own systems.

Still closer examination will reveal other features. In the first place, there are none of the green leaves usually found on plants. Secondly, there is no root fastening the plant to the soil. Why is this? What is the reason that this plant grows and flourishes like other plants, and has yet neither root nor leaves? Let us see.

What is known as parasitism in plants is not confined to any one family or class. Various orders have one or more genera with species which take their nourishment in a complete or partly elaborated form from other plants. Sometimes they are perfect parasites, and take everything they need from other vegetable forms. Sometimes, as in the mistletoe, they take the partially made sap, and complete its transformation within their own tissue; while in still other instances only a very little of the sap is taken, and the other nourishment is absorbed from the soil by the roots proper.

Our dodder is an example of a perfect parasite. All the material necessary for its growth it takes ready made from the plants upon which it grows. As the purpose of leaves in all plants is to prepare from the crude materials in the air and soil the matter necessary for its growth, and as the dodder finds and appropriates this material already made, the absence of leaves is at once accounted for. There was no need for them, and they ceased to be.

The want of a root is another matter. When the seed of the dodder is examined, it is found that there is simply a coiled embryo, with very little albumen. The usual seed-leaves are absent; so that, for its first growth, it must depend entirely upon the albumen in the seed. When this seed first germinates, a little rootlet penetrates the ground. Owing to the deficiency of food, it only exists long enough to enable its stem to grow till it reaches some plant upon which it can fasten. When this is accomplished, the young plant will grow rapidly, and soon sever its connection with the ground; but, if not able to reach some support, it dies entirely.

In order to comprehend the reasons for the peculiarities of the dodder, and understand how it came to assume its habit of complete parasitism, it will be necessary to notice the probable rise and progress of the habit. We can do this by looking at some of those plants which are not yet such complete pensioners on the bounty of others. For it very seldom happens that all the steps leading from a normal to an out-of-the-way mode of living are lost. Some few will remain, to indicate the line along which the plant has proceeded. Imperfect adaptations point surely the path leading to perfect development.

The modes of living of the dodder and the Indian pipe may be considered as the two extremes of one line of development. The first is a complete parasite, and the second has gone so far as to become a saprophyte. The central point from which sprang the two branches

is probably represented in certain species of *Gerardia*. Here is found the first indication of the parasitic habit. While the roots are attached to those of other plants, its green leaves are well developed, and it takes only the crude material into its system and there elaborates it; and at the same time it absorbs matter by means of the other roots with which it is provided.

The mistletoe comes second. In this plant we find the root absorbing nourishment from the branch on which it has located; the stem provided with green leaves, to which it can bring the sap to a proper state for assimilation, but no connection with the soil. The next step would be for the plant to loose its connection with earth or branch, take the fully elaborated sap, and by gradual stages lose all its foliage organs. Then the fully formed parasitic dodder results.

Proceeding in the opposite direction we find the beech-drop, a plant which lives in the rich mold of beech-woods, taking part of its food from the decaying leaves, and part from the roots of the beech-trees which it penetrates with its own rootlets. This plant is entirely destitute of green leaves, is of a brownish color, and may be considered one step on the road taken by the Indian pipe.

The Indian pipe, again, is a little plant which lives in the *débris* of forests, finding its food in the mass of decaying vegetable mold. While it is not probable that its roots are connected with those of the trees under which it grows, it is certain that the rich matter there found contains the constituents it requires for its growth. It, like the dodder, is destitute of green leaves, and for the same reason, namely, because it finds its food already prepared for it and has only to absorb it. But it differs in taking the food from the dead and decayed matter, instead of from the living. Plants of this kind are known as saprophytes, and are most common among the fungi. Here, then, in the saprophytic Indian pipe we have one end of a line of habit of living which has its other end in the perfect parasitism of the dodder.

In attempting to trace the origin of any particular habit peculiar to any one species, it is always necessary to examine the near relatives and see in what respects they resemble and in what ones they differ from the plant under consideration. The dodder belongs to the *Convolvulaceæ*, or the morning-glory family, and one of the most striking features of this family is found in their habits of twining. But what a vast difference there is in appearance between the morning-glory, with its large leaves, its root, and its conspicuous flowers, and the dodder, with its yellow stem, complete absence of green leaves, and lack of root! How is the change to arise which will bring the dodder to its present condition?

Evolutionists acknowledge that all changes in either plants or animals are the results of changes in conditions or surroundings. When once a change has occurred which is beneficial in a certain way, the

probability is, that the plant or animal will continue to develop in that direction till it diverges widely from the original form. The struggle for existence will cause all the imperfect forms to be killed off, and only those will survive which are best suited to the altered conditions of life. Once let an organism begin to vary in any one direction, and there is no telling where or when it will stop. This much is certain, that it never ceases until the best results possible have been attained.

The chief characteristic, then, of the convolvulus family is the climbing habit. The origin of this habit is found in the fact that sunlight and air are two things needful for a plant's proper growth and development. In situations where these two things are found in limited quantities, plants with climbing habits and animals with arboreal instincts will abound. In Brazil, for instance, where immense tracts are covered with a dense forest-growth, it is noticed that all forms of animal life have become adapted to residence in trees. Many of them live there entirely. Monkeys seldom leave the tree-tops. Lizards and snakes and insects are there, and even man himself is often found living among the branches. So, too, plants form immensely long stems, reaching in many cases to the tops of trees a hundred feet high. The extraordinary development of climbing powers has been gradually acquired in the course of ages. In times and places where vegetation was not dense, and where the struggle for light was not great, plants of erect habit succeeded well. Then it was a conflict to see which could grow tallest. But when a weak plant found that, by taking hold of its tall and erect neighbor and by clinging to it, it could reach the sunlight much easier and by an expenditure of much less material than by growing erect itself, it was a great step on the road. This habit, being transmitted from one generation to the next, kept on improving. Less and less rigid, more and more flexuous stems ensued, and the delicate climbing vines of modern times are the results of this necessity of reaching sunlight with as little waste of material as possible.

There are many methods adopted by plants to climb. While some of them reach upward by means of tendrils developed at the ends of stems or leaves, others twist their petioles round the support, and still others twine their stems round other stems that may come in their way. This last is the method adopted by those of the *Convolvulaceæ* which climb at all. For even in this family there are some species which are erect in growth. The *Calystegia spithamæa* is one of them. Others do not grow up into the air, but trail along the ground or over low plants, and thus secure their due share of sunlight. Others, again, climb freely, and this is the case with the dodder.

The climbing bitter-sweet is said to sometimes strangle the trees upon which it grows. The constriction caused by its growing stem is so great as to cut off the supply of sap from the roots, and cause the

death of the tree which has supported it. The original ancestor of the dodder was a plant with a well-developed root, green stem and leaves, and a twining habit. If its clasping killed the stem which supported it, the effect would be disastrous, for then it would not accomplish the purpose of its climbing. If the twining stem sank into the supporting one, it might cause decay along the line. This decaying would tend to develop rootlets from the side of the climber. The rootlets, used at first merely to assist in climbing, might and must have become modified so as to penetrate the bark to the tissue beneath. A minute absorption of the sap from this would be an assistance. Gradual increase of the amount absorbed would lead to gradual increase in the number of rootlets. And, this continuing, less and less need would be felt for the leaves. As needless organs are sure to degenerate, the leaves would become smaller and smaller, lose more and more of their green color, and finally become the yellow scales and bracts they now are.

Along with the loss of the leaves would go the root. Becoming less necessary, it would get smaller, until finally it would retain only enough of its original character to give the plantlet a start in life, and transmit its qualities to its progeny. Of course, all these changes would be made slowly; but they would come surely. If each succeeding generation of rooting stemmed plants throve better in any way, perfected seed in any greater abundance, or were enabled to crowd out competitors in the struggle for life, we may be sure that the descendants of the favored plants would inherit these good traits, and would send more and more rootlets into the enveloped stem, until at last the habit would become firmly fixed. Thus would be formed a leafless, rootless parasite, so well adapted to hold its own that it would probably exterminate some of the less favored forms.

The commencement of the habit of sending rootlets into stems has been observed in occasional specimens of the convolvulus. Let but this habit grow and be improved upon, as it surely will be if it is found beneficial, and from this small beginning we can look for just such a development as has been found in the dodder. It can not be said that there is always an upward progress in Nature. Degenerate forms exist and thrive as well as regenerate ones. The truth is, that when a plant or an animal can fill a vacant space in the world better by going backward than by going forward, the retreat is sounded. Progress or retrogression, it is the same. The direction best suited to Nature's needs is the one taken; so that, while on the one hand there may be a wonderfully complex organism, perfectly fitted for the struggle for life, on the other hand there may be a very degenerate one equally fitted into its place.

SUN-KINKS.

By T. O'CONOR SLOANE, Ph. D.

IN a recent journal of this city an article descriptive of a railroad accident appeared, under the heading, "Derailed by a Sun-Kink." The title doubtless puzzled many readers. The term indicates that the rails were thrown out of line by expansion, due to the heat of the sun. Few accidents are attributed to this cause, though it may be responsible for more than are supposed. It will be interesting to determine a few maxima of distortion that can be thus produced.

The expansion of metals under the influence of heat is very slight. A mile of iron rails, for an elevation of temperature of 100° Fahr., only expands two feet eight and one half inches. This is so little as to be readily taken up by the one hundred and seventy-six joints that exist in that length of rails. If the rails were laid in very cold weather, in solid contact with each other, then, on a warm, sunny day, a considerable disalignment could be produced. To find the maximum for the mile of rails, we must suppose that the line breaks in the middle, and bulges out like a flattened letter V. In this condition of things, the broken line of rail, with the original line for base, would form an equilateral triangle. The altitude of the triangle may be calculated by the familiar rule of the reverse of the hypotenuse. It will be found equal to nearly ninety feet. The result, though deduced by the simplest of calculations, is an astonishing one. It is enough to account for any number of "sun-kinks." The books are very prolific of instances of expansion by heat, and always speak of the expansion of rails. They do not, however, allude to the geometrical element of danger; they concern themselves only with the physical one.

It is obvious that a mile of rails would never expand in this way. Disturbances of alignment would be confined to smaller sections. The calculation shows a maximum that would never be attained. The conditions might be fulfilled by four rails. For the given elevation of temperature they would expand about eight tenths of an inch, with a lateral displacement of over two feet. For an expansion through 50° Fahr., the displacement would be eighteen inches.

Two rails would act in accordance with the supposition most readily. Their total expansion, for 100° Fahr., is four tenths of an inch, and the bulge due to such expansion would be twelve inches. For half the number of degrees it would be nine inches. This shows how very small a rise of temperature might produce a spreading sufficient to throw a train from the track. The smaller figures are as impressive as the ninety feet, when it is recollected that four inches displacement of the rails might produce a catastrophe.

The distortion might be confined to a single rail; and, from what

has been said, it is clear how seriously the small fraction of an inch of expansion could affect it. It is an application of the old law of the elbow-joint press reversed, the working pressure taking the place of the resistance. The work is done at a great disadvantage, but the power is almost limitless.

A very good instance of "sun-kink" could be seen some years ago on the wooden bridge leading from the elevated railroad station at One Hundred and Fifty-fifth Street, in this city, toward Ninth Avenue. A gas-pipe of wrought-iron was laid on the floor of the structure. As if to render it more susceptible to the rays of the sun, it was painted of dark color. On cold or cloudy days it lay in its normal position. On sunny days, the writer has frequently seen it bowed outward nearly or quite a foot out of line. The surface of the foot-planks under this part of it became worn by the daily friction. Finally, an arrangement of bends was introduced that operated as an expansion-joint, and now no bowing takes place.

Even 50° Fahr. seems a large rise in temperature. But it must be remembered that the temperature of rails, or similar objects, is affected by the radiant heat of the sun as well as by the atmospheric temperature. The latter is only the initial factor. The sun's rays could easily raise their absolute temperature above 100° Fahr.

NATIONAL HEALTH AND WORK.*

By Sir JAMES PAGET, F. R. S.

IT was very difficult to select, from the vast number of subjects relating to health and to education, one of which I could fitly speak today. On general education I could not venture to speak; and, believing that I should have to address a large and various audience, I thought it would be best to choose a subject by which I might urge one of the chief objects of this Exhibition, and one which I know that you, sir, have always had in view, namely, that the public themselves should consider, much more than they do, the utility and the means of maintaining their own health. I have, therefore, chosen the relation between the national health and work; especially as it may be shown in a few of the many examples of the quantity of work which is lost to the nation, either through sickness or through deaths occurring before the close of what may fairly be reckoned as the working-time of life. I think it may be made clear that this loss is so great, that the consideration of it should add largely to the motives by which all people may be urged to the remedy of whatever unwholesome conditions they may live in. It is a subject which is often in the minds of the real students

* Address delivered at the International Health Exhibition, London, June 17, 1884.

of the public health, but the public itself is far too little occupied with it.

I shall speak only of national health. In consideration of his own self, a man may be deemed healthy who lives idle, comfortably, and long; who enjoys every day of his life, and satisfies every natural appetite without consequent distress. And when such a one dies of old age, with a timely, uniform, and painless decay of every part, he may be deemed to have been completely healthy. And yet it is possible that he may have enjoyed his own health in the midst of a poor, unhealthy, and unhappy nation, to which he has done no good whatever.

If we could find a nation composed of people such as this man, we might be bound to speak of them as healthy; but we should be right in calling the whole nation utterly unsound, and might safely prophesy its complete stagnation, or its quick decline and fall.

It is not health such as this—idle, selfish, unproductive—that we want to promote either in the individual or in the multitude. Comfortable idleness, such as that of some vagrants and fine gentlemen, is a despicable result of good health; it is what no thorough man would ever wish for. In view of the national health and welfare, the pattern healthy man is one who lives long and vigorously; who in every part of his life, wherever and whatever it may be, does the largest amount of the best work that he can, and, when he dies, leaves healthy offspring. And we may regard that as the healthiest nation which produces, for the longest time, and in proportion to its population, the largest number of such men as this, and which, in proportion to its natural and accumulated resources, can show the largest amount and greatest variety of good work.

Here let me insert, as an interpretation clause, that in all this and what is to follow the word "man" means also "woman," and "he" means also "she"; and that, when I speak of work, I mean not only manual or other muscular work, but work of whatever kind that can be regarded as a healthy part of the whole economy of the national life. And I shall take it for granted that a large portion of all national welfare is dependent on the work which the population can constantly be doing; or, if I may so express it, that the greater part of the national wealth is the income from the work which is the outcome of the national health.

It is a common expression that we do not know the value of a thing till we have lost it; and this may be applied to the losses of work which are due to losses of national health. There are very few cases in which these can be estimated with any appearance of accuracy; but I am helped to the best within our present reach by Mr. Sutton, the Actuary to the Registry of Friendly Societies. In his office are the returns, for many years past, of the sickness and mortality among the members of a very large number of these societies; and, among other things, there is recorded the number of days which each member, when

"off work" on account of sickness, receives money from his society. Hence Mr. Sutton can estimate, and this he has been so good as to do for me, the average number of days' sickness and consequent loss of work among several hundred thousands of the workmen and others who are members of these societies. From the entire mass of these returns, he deduces that the average number of days' sickness, per member per annum, is very nearly one and a half week; and this agrees, generally, with the estimates made in other societies by Mr. Neison and others. But the averages thus obtained include the cases of members of all ages, and among them many cases of chronic sickness and inability to work during old age. In order, therefore, to get a better idea of the actual annual loss of work through sickness, he has calculated the average annual number of days' sickness of each person during what may be deemed the normal working-time of life; that is, between fifteen and sixty-five years of age. This he has done among the members of the large group of friendly societies known as the Manchester Unity of Odd-Fellows; and then, on the fair assumption that the rates of sickness of the whole population during the working years of life would not be far different, he has calculated the following tables, showing the average annual rates of sickness of each person enumerated in the census of 1881, as living between the ages of fifteen and sixty-five:

AGES.	Number of males: Census of 1881 (England and Wales).	Weeks' sickness per annum, according to the experience of the Manchester Unity.	Average sickness per individual per annum (in weeks).
15 to 20.....	1,268,269	844,428	·666
20 to 25.....	1,112,354	820,183	·737
25 to 45.....	3,239,432	3,224,134	·995
45 to 65.....	1,755,819	4,803,760	2·736
All ages from 15 to 65.....	7,375,874	9,692,505	1·314

AGES.	Number of females: Census of 1881.	Weeks' sickness per annum, according to the experience of the Manchester Unity.	Average sickness per individua per annum (in weeks).
15 to 20.....	1,278,963	851,701	·666
20 to 25.....	1,215,872	896,685	·737
25 to 45.....	3,494,782	3,476,146	·995
45 to 65.....	1,951,713	5,368,229	2·751
All ages from 15 to 65.....	7,941,330	10,592,761	1·334

Briefly, it appears from these tables that the average time of sickness among males during the working years is 1·314 weeks—that is, a small fraction more than nine days in each year—and that among females it is a small fraction more. The result is, that among males

there is a loss of 9,692,505 weeks' work in every year, and among females a loss of 10,592,761 weeks. Thus we may believe that our whole population between fifteen and sixty-five years old do, in each year, 20,000,000 weeks' work less than they might do if it were not for sickness. The estimate is so large that it must, on first thoughts, seem improbable; but on fair consideration I believe it will not seem so. For the members of the Manchester Unity who are in the working-time of life, the reckoning is certainly true, and it is founded on the experience of between 300,000 and 400,000 members. In respect of health they may represent the whole population, at least, as well as any group that could be taken. They are not very strictly selected—they are not picked lives; yet they are such as are able, when they are in health, to earn good wages or good salaries, and, as their prudence in joining this association shows, they are comparatively thrifty and careful persons. They do not, at all events, include many of the habitual drunkards, the cripples or utterly invalids, or those who, through natural feebleness or early disease, or mere profligacy, can not earn enough to become members or maintain themselves in membership. Neither do they include many of the insane, or imbecile and idiotic, of whom there are, in our population, nearly 70,000, doing no work, and losing not less than 3,500,000 weeks' work in the year.

It would be tedious to tell the grounds on which the estimate may be deemed too high, for just as many and as good could be told on which it might be deemed too low. And it is rather more than confirmed by some estimates of the annual sickness in other and very different groups of persons.

In the army, at home, the average number of days' sickness in each year is, for each soldier, about seventeen; and, as the number of the troops in the United Kingdom is more than 80,000, we have here a loss of about 200,000 weeks' service in each year.

In the navy, on the home stations, the average number of days' sickness in each year has been in the last five years for each man nearly sixteen; so that for the total of about 20,000 men there is a loss of 45,000 weeks' service in each year.

The amount of sickness in the services thus appears much higher than in the friendly societies. This is due, in great part, to the fact that a soldier or a sailor is often put off duty a day or two for much less illness than that for which a civilian would "go on his club." Still, the one estimate may confirm the other; for the sickness in the army and navy is that of picked men, who were selected for the services as being of sound constitution, and who are in what should be the best working years of life: and, if it includes many cases of sickness for only a day or two, it excludes nearly all cases of more than a few months, such as make up a heavy proportion of the average sickness in the friendly societies and in the general population.

And I may add that the estimate from these societies, that nine

days in the year may justly be thought a fair estimate of the working-time lost by sickness, is confirmed by the records of sickness among the 10,000 members of the metropolitan police force; for among these, including cases of long illness such as are also in the societies, the average is more than nine days in the year.

I think, then, that we can not escape from the reasons to believe that we lose in England and Wales, every year, in consequence of sickness, 20,000,000 weeks' work; or, say, as much work as 20,000,000 healthy people would do in a week.

The number is not easily grasped by the mind. It is equal to about one-fortieth part of the work done in each year by the whole population between fifteen and sixty-five years old. Or, try to think of it in money. Rather more than half of it is lost by those whom the Registrar-General names the domestic, the agricultural, and the industrial classes. These are more than 7,500,000 in number, and they lose about 11,000,000 weeks; say, for easy reckoning, at £1 a week; and here is a loss of £11,000,000 sterling from what should be the annual wealth of the country. For the other classes, who are estimated as losing the other 9,000,000 weeks' work, it would be hard and unfair to make a guess in any known coin; for these include our great merchants, our judges and lawyers, and medical men, our statesmen and chief legislators; they include our poets and writers of all kinds, musicians, painters, and philosophers; and our princes, who certainly do more for the wealth and welfare of the country than can be told in money.

Before I speak of any other losses of work or of wealth due to sickness, permit me, as in parentheses, to point out to you how very imperfectly these losses are told, or even suggested by our bills of mortality. These, on which almost alone we have to rely for knowing the national health—these tell the losses of life, and more than misery enough they tell of; but to estimate rightly the misery of sickness, and the losses of all but life that are due to it, we need a far more complete record than these can give.

Take, for example, such a disease as typhoid fever—that which Mr. Huxley has rightly called the scourge and the disgrace of our country. It has of late destroyed, in England and Wales, among persons in the working-time of life, nearly 4,000 in the year. Its mortality is about fifteen per cent, so that, if in any year 4,000 die of it, about 23,000 recover from it. Of these, the average length of illness is, on the authority of Dr. Broadbent, about ten weeks. Here, therefore, from one disease alone, and that preventable, we have an annual loss of 230,000 weeks' work, without reckoning what is lost with those who die. And the same may be said of nearly all the diseases that are most prominent in the bills of mortality. The record of deaths, sad as it is, tells but a small part of the losses of happiness and welfare that are due to sickness. It is as if in a great war we should have a regular return of the numbers killed, but none of the numbers

wounded, though these, more than the killed, may determine the issue of the war.

Let me now tell of another loss of work and of money through sickness and early death. In all the estimates I have yet referred to, no account is taken of those who are ill or die before they are fifteen years old. They are not reckoned as in the working-time of life, though in some classes many thousands of them are. (In the domestic, agricultural, and industrial classes of the Registrar-General nearly half a million of them are included.) And yet the losses of work due to sickness among children must be very large. Consider the time which might be spent in good productive work, if it were not spent in taking taking care of them while they are ill. Consider, too, the number of those who, through disease in childhood, are made more susceptible of disease in later life, or are crippled, or in some way permanently damaged; such as those who become deaf in scarlet fever, or deformed in scrofula or rickets, or feeble and constantly invalid, so that they are never fit for more than half-work, or for work which is only half well done. These losses can not be counted, but they must be large; and there are others more nearly within reckoning; the losses, namely, which are due to the deaths of those who die young. If they had lived to work, their earnings would have been more than sufficient to repay it; but they have died, and their cost is gone without return. The mortality of children under fifteen in 1882 was nearly a quarter of a million; what have they cost? If you say only £8 a piece, there are more than £2,000,000 sterling thus lost every year. But they have cost much more than this, and much more still is lost by the loss of the work they might have lived to do.

It is, indeed, held, I believe, by some that these things should not be counted as losses; that we have a surplus of population, and that really the deaths of children, though they may be the subjects of a sentimental sorrow, can not reasonably be regretted. I can not bring myself to admit that such a thing should even be argued. I have lived long in the work of a profession which holds that wherever there is human life it must be preserved; made happy, if that can be; but, in any case, if possible, preserved; and no argument of expediency shall ever make me believe that this is wrong. Indeed, I am rather ashamed—even for the purpose I have in view—to use so low an argument as that of expediency in favor of the saving of health and of life. I am ashamed of making money appear as a motive for doing things for which sufficient motives might be found in charity and sympathy, and the happiness of using useful knowledge; but it seems certain that these are not yet enough for all that should be done for the promotion of the national health; therefore, it seems well to add to them any motives that are not dishonorable; and so I add this, that we lose largely not only in happiness but in wealth by the deaths of these poor children.

I will add only one more illustration of these losses, which is always suggested by looking at tables of mortality. The deaths of persons between twenty-five and forty-five years old, that is during what may be deemed the twenty best working years of life, are annually between 60,000 and 70,000; in 1882 they were 66,000. Think, now, of the work lost by these deaths; and of how much of it might have been saved by better sanitary provisions. If one looks at the causes of their deaths, it is certain that many might have been prevented, or, at least, deferred. Say that they might have lived an average of two years more; and we should have had in this year and last an increase of work equivalent to that of at least 6,000,000 weeks; as much, in other words, as 6,000,000 people could do in one week.

More instances of losses of work by sickness and premature death might easily be given, but not easily listened to in this huge hall. Let these suffice to show something of our enormous annual loss, not only of personal and domestic happiness—that is past imagining—but of national power and wealth. Surely we ought to strive more against it.

But, some may ask, can these things be prevented? are they not inevitable consequences of the manner of life in which we choose or are compelled to live? No; certainly they are not. No one who lives among the sick can doubt that a very large proportion of the sickness and the loss of work which he sees might have been prevented; or can doubt that, in every succeeding generation, a larger proportion still may be averted, if only all men will strive that it may be so.

Let me enumerate some of the chief sources of the waste as they appear to one's self in practice.

Of the infectious fevers, small-pox might be rendered nearly harmless by complete and careful vaccination. Typhus and typhoid, scarlet fever and measles might, with proper guards against infection, be confined within very narrow limits. So, probably, might whooping-cough and diphtheria.

Of the special diseases of artisans there are very few of which the causes might not be almost wholly set aside. Of the accidents to which they are especially liable, the greater part, by far, are due to carelessness.

Of the diseases due to bad food and mere filth; to intemperance; to immorality—in so far as these are self-induced—they might, by self-control and virtue, be excluded. And with these, scrofula, rickets, scurvy, and all the wide-spread defects related to them, these might be greatly diminished.

It can only be a guess, but I am sure it is not a reckless one, if I say that of all the losses of work of which I have spoken, of all the millions of weeks sadly spent and sadly wasted, a fourth part might have been saved, and that, henceforth, if people will have it so, a still larger proportion may be saved.

We may become the more sure of what may be done by looking at what has been done already. Let me show some of it; it will be a relief to see something of the brighter side of this picture.

In a remarkable paper lately read before the Statistical Society, Dr. Longstaff says, "One of the most striking facts of the day, from the statistician's point of view, is the remarkably low death-rate that has prevailed in this country during the last eight years." In these years the annual death-rate has been less than in the previous eight years in the proportion of two deaths to every 1,000 persons living. The average number of deaths has been 50,000 less in the last than in the previous eight years. Doubtless many things have contributed to this grand result, and it is not possible to say how much is due to each of them; but it would be unreasonable to doubt that the chief good influence has been in all the improved means for the care of health which recent years have produced. This is made nearly certain by the fact that the largest gains of life have been in the diminution of the deaths from fever, and of the deaths in children under fifteen years old; for these are the very classes on which good sanitary measures would have most influence.

The annual number of deaths from typhus, typhoid, and the unnamed fevers, has been about 11,000 less than it was about twenty years ago. The annual number of deaths of children under five years old has been about 22,000 less than it was; and that of children between five and fifteen has been upward of 8,000 less.

These are large results, and, though they tell only of deaths, yet they bear on the chief subject I have brought before you—the working power of the nation; for, however much we might assign to improved methods of medical treatment of fever, yet the diminished number of deaths means a very large diminution in the total number of cases. The deaths during the working years of life were 6,500 less; and, this being so, we may hold that, if the average mortality was, say, twenty-five per cent, the diminution in the total number of cases must have been at least 25,000; and if we may believe, as before, that each of these involved ten weeks of sickness, we have, in these fevers alone, a clear saving of 185,000 weeks' work in every year.

And so with the diminution of the mortality among children, there must have been a greater diminution in the number of costly and work-wasting illnesses, and a large saving of money that would otherwise have been sunk. And not only so: but many of the children saved in the last eight years will become bread-winners or care-keepers; and who can tell what some of them will become; or what the world would have lost if it had lost all of them?

Let me add only one more reckoning. In a paper last year, at the Statistical Society, Mr. Noel Humphreys showed that "if the English death-rate should continue at the low average of the five years 1876–'80, the mean duration of male life in this country would be

increased by two years, and that of female life by no less than 3·4 years as compared with the English life-table." And he showed further that "among males seventy per cent and among females sixty-five per cent of this increased life would be lived between the ages of twenty and sixty years, or during the most useful period."

I should like to be able to tell the value in working-power of such an addition to our lives. It is equal to an addition of more than four per cent to the annual value of all the industry, mental and material, of the country.

But some will say—admitting that it is desirable, seeing how keen the struggle for maintenance already is, Can more than this be done? and the answer may be and must be, Much more. In this, as in every case of the kind, every fruit of knowledge brings us within reach of something better. While men are exercising the knowledge they possess, they may be always gaining more. This Exhibition has scores of things which are better helps to national health than those of the same kind which we had twenty years ago, and with which the gains already made were won. If I were not in near official relation with the jurors, I would name some of them: there are truly splendid works among them.

But do not let me seem to disparage the past in praising the present. It is difficult to speak with gratitude enough of what has been done, even though we may see, now, ways to the yet better.

Any one, who has studied the sources of disease during the last thirty years, can tell how and where it has diminished. There is less from intemperance, less from immorality; we have better, cheaper, and more various food; far more and cheaper clothing; far more and healthier recreations. We have, on the whole, better houses, and better drains; better water and air; and better ways of using them. The care and skill with which the sick are treated in hospitals, infirmaries, and even private houses, are far greater than they were; the improvement and extension of nursing are more than can be described; the care which the rich bestow on the poor, whom they visit in their own homes, is every day saving health and life; and, even more effectual than any of these, is the work done by the medical officers of health, and all the sanitary authorities now active and influential in every part of the kingdom.

Good as all this work has been, we may be sure it may become better. The forces which have impelled it may still be relied on. We need not fear that charity will become cool, or philanthropy inactive, or that the hatred of evil will become indifference. Science will not cease to search for knowledge, or to make it useful when she can; we shall not see less than we do now, and here, of the good results of enterprise and rivalry, and of the sense of duty and the sorrow of shame that there should be evil in the land.

What more, then, it may be asked, is wanted? I answer, that

which I have tried to stir: a larger and more practical recognition of the value and happiness of good national health; a wider study and practice of all the methods of promoting it; or, at least, a more ready and liberal help to those who are striving to promote it. In one sentence, we want the complete fulfillment of the design of this Exhibition, with all the means toward health and knowledge that are shown in it, and with its hand-books, lectures, conferences, and the verdicts of its juries.

We want more ambition for health. I should like to see a personal ambition for renown in health as keen as is that for bravery, or for beauty, or for success in our athletic games and field-sports. I wish there were such an ambition for the most perfect national health as there is for national renown for war, or in art or commerce. And let me end soon by briefly saying what I think such health should be.

I spoke of the pattern healthy man as one who can do his work vigorously wherever and whatever it may be. It is this union of strength with a comparative indifference to the external conditions of life, and a ready self-adjustment to their changes, which is a distinctive characteristic of the best health. He should not be deemed thoroughly healthy who is made better or worse, more or less fit for work, by every change of weather or of food; nor he who, in order that he may do his work, is bound to exact rules of living. It is good to observe rules, and to some they are absolutely necessary, but it is better to need none but those of moderation, and, observing these, to be able and willing to live and work hard in the widest variations of food, air, clothing, and all the other sustenances of life.

And this, which is a sign of the best personal health, is essential to the best national health. For in a great nation, distributed among its people, there should be powers suited to the greatest possible variety of work. No form or depth of knowledge should be beyond the attainment of some among them; no art should be beyond its reach; it should be excellent in every form of work. And, that its various powers may have free exercise and influence in the world, it must have, besides, distributed among its people, abilities to live healthily wherever work must be or can be done.

Herein is the essential bond between health and education; herein is one of the motives for the combination of the two within the purpose of this Exhibition; I do not know whether health or knowledge contributes most to the prosperity of a nation; but no nation can prosper which does not equally promote both; they should be deemed twin forces, for either of them without the other has only half the power for good that it should have.

It is said, whether as fact or fable, that the pursuit of science and of all the higher learning followed on the first exercise of the humanity which spared the lives of sick and weakly children; for that these children being allowed to live, though unfit for war and self-main-

tenance, became thinkers and inventors. But learning is not now dependent on invalids; minds are not the better now for having to work in feeble bodies; each nation needs, for its full international influence, both health and knowledge, and such various and variable health, that there should be few places on earth or water in which some of its people can not live, and multiply, and be prosperous.

If, therefore, we or any other people are to continue ambitious for the extension of that higher mental power of which we boast, or for the success of the bold spirit of enterprise with which we seek to replenish the earth and subdue it; if we desire that the lessons of Christianity and of true civilization should be spread over the world, we must strive for an abundance of this national health—tough, pliant, and elastic—ready and fit for any good work anywhere.—*Journal of the Society of Arts.*

THE MORALITY OF HAPPINESS.

By THOMAS FOSTER.

CARE OF OTHERS AS A DUTY.—(CONTINUED.)

BUT we recognize the necessity of a more thorough altruism than that which merely considers the rights of others. That a community should progress as it ought, each member of the body social should feel that it is a part of his personal duty to consider the well-being of the rest. The weakness and the want of skill, the ill-health and the imperfect education of his fellows, are injurious to him and to all. In such degree as weakness or want of skill affects the productive power of some members of the community, the comfort and happiness of the stronger and more skillful are affected. The weak and inefficient members, who can not provide for themselves, must be provided for somehow. The trouble to the community which would arise from any plan for leaving the weak and unskillful unprovided for would be much more serious than the loss arising from the efforts made to help them. But these efforts being so much deducted from the general efforts of the stronger and more skillful members of the body social must be counted as loss. So that it is the interest of all to see that there may be as few weak and unskillful persons in the community as possible.

In like manner the sickness of our fellows is a matter in which we are interested. Apart from the necessity of restoring the sick to such health and strength as may fit them to take their part in the work of the community, the illness of others may bring illness to ourselves. Fever and pestilence, though they may first attack the weak, presently extend their attacks to those who had been strong. If even a man

should feel no anxiety on his own account, those dear to him, those dependent on him, or those on whom perhaps he is in greater or less degree dependent, may succumb to such attacks. Considering all the evils, near and remote, which may follow from an epidemic, we recognize the necessity of adopting all such altruistic measures as may avail to diminish the chance of such diseases arising, or to limit their range of action when they have once found footing. No doubt egoistic considerations here seem to suggest altruistic duties; but these altruistic duties can not be properly undertaken or discharged unless they have become habitual and are referred to a real care and regard for others independently of consequences, more or less remote, to self. Apart from which, the discharge of such altruistic duties will be more satisfying and more pleasant if they are spontaneously undertaken.

Similar considerations apply to education in all its various forms. In other words, we must consider the mental as well as bodily weaknesses, and the mental as well as bodily diseases, of our fellow-citizens. Where those around us are stupid and unintelligent, where they attempt no improvements, where they have little inventive capacity and little readiness to use even such as they have, we suffer along with them. The mere stupidity of the great mass of most communities with regard to the system of government they consent to be ruled by may mean most serious injury and discomfort to all, foolish and intelligent alike. Those who see what is needed, or at least the direction in which improvement may reasonably be sought, yet remain silent in the belief that it is no business of theirs, are as unintelligent as those who stupidly assent to what—without thinking—they suppose to be good for them and to be provided for by those who know better than themselves; though often, when traced to their source, the measures in vogue are found to be of no better origin than the body itself which submits to them.

A low standard of intelligence in the community affects the welfare of all, in many different ways. Wrong ideas about the relation of the nation to other nations may seem unimportant in the case of persons who take no direct part in political matters. But in reality a very notable influence is exerted by the community generally on the conduct of those who have charge of political affairs. Wrong counsels in the cabinet may be advanced or right counsels hampered by stupidity in the country at large. Statesmen themselves are not always so wise or often so firm that they are not influenced by prevalent ideas; and so far as mere numbers are concerned prevalent ideas are likely to be foolish ideas. Fortunately, mere numbers may not suffice to give weight to prevalent stupidity. Many of the unwise are influenced by the observed fact that such and such men conduct affairs successfully, and so are led to support the wiser sort, not through sound judgment on their own part, but from that kind of sense which leads the ignorant to defer to the judgment of the better-informed. But this does

not prevent the average intelligence of the community from being a matter of great moment even in political matters—supposed to be guided always by the wisest, despite the true saying that the world is governed with but a small amount of wisdom. What I have here said has no relation to the action of kings, princes, and the like, who in English-speaking communities can not now injuriously influence political relations except through the weakness or folly of statesmen. Yet the argument might be strengthened by calling attention to the way in which, even within the last thirty years, our own country has suffered in this special direction, statesmen weakly or foolishly yielding to public pressure by which the unwise counsels of princes have been supported. A hundred years ago our country saw in still more marked way how the average want of intelligence of the many, supporting the stupidity of a king (of alien race, in that case), may go near to wreck the fortunes of a great race. We may hope, however, that no such trouble is in store for us hereafter as afflicted the British people when a foolish people insanely strengthened the hands of a mad king.

In social matters a low standard of general intelligence is a serious evil, which a wise altruism will endeavor to diminish. "*I do not mean*," I may here say with Mr. Herbert Spencer, "*such altruism as taxes rate-payers that children's minds may be filled with dates and names and gossip about kings and narratives of battles and other useless information, no amount of which will make them capable workers or good citizens; but I mean such altruism as helps to spread a knowledge of the nature of things, and to cultivate the power of applying that knowledge.*"

It is hardly necessary to multiply examples. We are confronted at every step by the harmful effects of prevalent want of intelligence. The fire which is intended to warm your room is so stupidly placed that it sends the better part of the heat up the chimney and creates cold draughts round your legs. Equally obnoxious to the understanding is the window by which you seek to ventilate your room. It is a struggle to open it, a struggle to close it, unless when your head is in the way, when it generally descends in effective guillotine-fashion. The carpeting of your room is an absurdity, the papering (apart from any question of beauty) a monstrosity. The gaseliers are so ingeniously arranged that you get a minimum of light and a maximum of heat and foul air. The chair you sit on seems intended to make you uncomfortable; as you draw it up to the table you find that the senseless people who plan furniture have provided sharp corners just where your knees are most likely to be caught. If you wish to lie down or to recline on a sofa, you find the head of the sofa so ingeniously padded that, while too sloped for reclining, it is not sloped enough for you to lie on it comfortably.* Your child, running in for a kiss from

* I fear Mr. Foster refers to that abomination of desolation, the Alexandra sofa, which certainly for hideousness and utter unfitness for all the uses of a sofa is a marvel of

papa, stumbles over a footstool so carefully colored like the carpet that it did not catch his eyes but his feet; and, falling, is hurt severely by a sharp projection on chair, sofa, table-leg, fender, scuttle, or what not, where no sharp projections are wanted, and none ever should be. In numberless ways miseries, individually small, but effectively diminishing happiness, result from general want of intelligence. "Unpunctuality and want of system," again, as Mr. Herbert Spencer points out, "are perpetual sources of annoyance. The unskillfulness of the cook causes frequent vexation and occasional indigestion. Lack of forethought in a house-maid leads to a fall over a bucket in a dark passage; and inattention to a message, or forgetfulness in delivering it, entails failure in an important engagement."

It is thus the interest of each one of us, and being also for the good of all becomes the duty of each, to be altruistic in regard to the mental progress of the community—"we benefit egoistically by such altruism as aids in raising the average intelligence."

But we are equally interested in the improvement of the moral feeling pervading the social body. The happiness of the whole community is diminished by the prevalence of unconscientious ways. In small matters as in large the principle prevails. We are all interested in helping to teach men the duty of considering the rights and claims of others. From the man who hustles others off the pavement or occupies an unfair share of what should be general conversation, to the man who swindles by gross aggressions or serious breach of contract, the products of a state of low average morality diminish the happiness of the community. The aggregate of discomfort wrought by paltry offenses is serious though each separate offense may produce but slight mischief. Moreover, offenses paltry in themselves may produce very serious results. The disobedience of a nurse in some small matter (such as taking her charge to this or that place) may lead to accident affecting life or limb, or to disease ending in permanent injury or in death. In other ways, mischievous results of greater or less importance are brought about by defective moral sense in small matters, while, when we consider the effects of want of conscientiousness in business, we recognize still more clearly how much we are all concerned in the moral improvement of the community. "Yesterday," says Mr. Herbert Spencer, "the illness of a child due to foul gases led to the discovery of a drain that had become choked because it was ill-made by a dishonest builder under supervision of a careless or bribed surveyor. To-day workmen employed to rectify it occasion cost and inconvenience by dawdling, and their low standard of work, deter-

idiotic absurdity. Nine tenths of our sofa and arm-chair patterns, however, are "too absurd for any use," as they say in America. Among my own pet abominations I may mention nearly all the methods (save the mark!) for curtaining windows, the ridiculous ways in which looking-glasses are swung, the preposterously unscientific forms of ink-stands, and some others *quæ nunc perscribere longum*.—R. P.

mined by the unionist principle that the better workers must not discredit the worse by exceeding them in efficiency, he may trace to the immoral belief" (well put!) "that the unworthy should fare as well as the worthy. To-morrow it turns out that business for the plumber has been provided by damage which the brick-layers have done." And so daily and hourly do we feel that the moral imperfections of the community are fit subjects for such altruistic efforts as may help to raise the average morality.

While we thus recognize that our well-being depends so greatly on the well-being of others—their health and bodily capacities, their sense and knowledge, and their moral qualities—that due regard for others is essential to the happiness of self, we see further that each member of the body social gains directly by the possession and exercise of such qualities as lead or enable him to help his fellows. Among the proverbs which present in brief the ideas of a race as to what is good and bad, are many which imply that regard for the interest and welfare of others is bad policy. Such proverbs can not be regarded as expressing "the wisdom of many" by "the wit of one," for experience proves abundantly that the policy of hardness and indifference is unwise and short-sighted. Even mere material success—which does not always mean happiness—is not advanced in the long-run by disregard of others. The man of business gains in unnumbered ways by consideration for the rights and interests of his fellow-workers, and loses in as many by selfish disregard for them. Nay, even in the trivial affairs of ordinary life, at home and abroad, the kindly and considerate gain constantly, while the careless and indifferent as constantly suffer. It is, however, when we consider happiness as distinguished from mere material success, and the general balance of comfort and enjoyment as distinguished from the effects of individual actions, that we see how much men gain by sympathetic and kindly conduct. We see even first-rate abilities and untiring energy beaten easily in the race of life by the kindliness which makes friends of all around and leads to opportunities which the hard and ungenial fail to obtain. But when we rightly apprehend the nature of life, and what makes life worth living, we find the chief gain of the kindly, not in these material opportunities, but in the pleasanter ways along which their life's work leads them. Compare two men, toward the evening of life, of whom both perhaps have achieved a fair amount of material success in life, but one of hard, unkindly manners, the other genial and sympathetic; one alone in life's struggle, the other with "troops of friends" from first to last. Who can doubt, as he compares the worn and weary look of one with the bright and cheerful aspect of the other, that regard for others counts for something toward the welfare and the happiness of self?

Care for others helps so surely in life's struggle that it would be good policy for the naturally hard man to benefit others for purely

selfish motives, and still better policy to cultivate kindliness and consideration as qualities sure to be fruitful of profit. The kindly nature which leads to spontaneous good-will toward others, independently of any consideration of gain to self, is even more profitable than cultivated kindliness. Those are lucky who possess such a nature—lucky rather than deserving of special credit, seeing that a sympathetic nature is born in a man, not made by culture. Yet the will has much to do with the development of kindliness; and many, by sensible reflection and constant watchfulness over the undue promptings of self, have trained themselves to a kindliness and geniality of manner such as they were not naturally gifted with, and this without any direct reference to self-interest, but as a matter of right and justice to their fellows. Such men deserve much credit for their care in correcting inherent tendencies to undue care of self. The increased happiness of their lives (in so far at least as happiness depends on conduct) is their reward.

Among the good effects of kindly regard for others we may note the reflected happiness derived from those around. Men vary with their company, and undoubtedly the man of sympathetic temperament whose presence is a pleasure to others finds others much pleasanter in their relations with him than they would be were he of hard, ungenial nature. The wife and children of the kindly man are a constant pleasure to him, where the wife and children of the sour-tempered, ungenial husband and father are apt to grow gloomy and quarrelsome. His friends and relatives are kindlier than those of the harsh and selfish. Abroad, he sees few faces which do not reflect something of his own brightness and cheerfulness. As Mr. Herbert Spencer well says: "Such a one is practically surrounded by a world of better people than one who is less attractive: if we contrast the state of a man possessing all the material means to happiness, but isolated by his absolute egoism, with the state of an altruistic man relatively poor in means but rich in friends, we may see that various gratifications not to be purchased by money come in abundance to the last, and are inaccessible to the first."

But in yet other ways do we find illustrated by the effects of due care for others the saying, "To him that hath shall be given, and from him that hath not shall be taken even that which he seemeth to have."

Not only has the hard and ungenial man fewer gratifications, but those which he has he enjoys less than the man who cares for the wants and wishes of others. The one loses the power of enjoyment through his over-anxiety for self-gratification, the other unconsciously pursues—through his kindliness of character—the very course which a wise and thoughtful consideration of the plan best qualified to secure self-gratification would suggest. The one, while caring unduly for himself, is exhausting and satiating his power to care for any form of pleasure, the other while ministering to the enjoyments of others is

fostering his own capacity for enjoyment. Here again, if one wished to suggest a course of action by which a man who suffered from life-weariness might again know the charm of happiness, one could advise no better course than to minister systematically to the enjoyments of those around. The very tide of life is made fuller thus, even as the tide of thought is made fuller by turning from mere reflection to a interchange of ideas and thoughts with those around. While there is work to be done in the way of increasing others' happiness, no man—not even the most jaded and satiated—need ask himself the sickly question, "Is life worth living?"

Especially is this so when the tide of life is ebbing. Mr. Spencer's words on this point are worthy of careful study, by those in particular who know of him only as the teacher of some hard, unsympathetic system of Gradgrindian philosophy, for they afford an apt example of his kindly and lovable teaching:

"It is in maturity and old age that we especially see how, as egoistic pleasures grow faint, altruistic actions come in to revive them in new forms. The contrast between the child's delight in the novelties daily revealed and the indifference which comes as the world around grows familiar, until in adult life there remain comparatively few things that are greatly enjoyed, draws from all the reflection that as years go by pleasures pall. And, to those who think, it becomes clear that only through sympathy can pleasures be indirectly gained from things that have ceased to yield pleasures directly. In the gratifications derived by parents from the gratifications of their offspring, this is conspicuously shown. Trite as is the remark that men live afresh in their children, it is needful here to set it down as reminding us of the way in which, as the egoistic satisfactions in life fade, altruism renews them while it transfigures them."

But not only does altruism increase the pleasures of life; the exercise of the altruistic qualities is in itself pleasurable. The state of mind when kindly actions are performed affords pleasure. It directly increases happiness, and thus (like other pleasures) enhances physical well-being. It is true that a sympathetic nature suffers where a hard and callous nature would feel no pain. Undue altruism has no doubt its bad effects, nor can it be denied that even such altruistic feelings as are desirable for the social well-being cause, at times, some degrees of suffering; but the exercise of the altruistic qualities is in the main pleasurable, and it can not be doubted that altruistic emotions give more pleasure than sorrow. When we sorrow for a friend's grief we experience pain and undergo such depression of the vital functions as always accompanies pain; but in the long-run the joy felt in sympathy with the joys of others surpasses the sorrow occasioned by their troubles.

Then, too, it must be remembered that those pleasures which we derive from the arts owe a large part of their value to altruistic emo-

tions. Consider the pleasure given by a painting representing a scene which moves our sympathies, or the delight with which we read some work of fiction in which kindly emotions are dealt with, and it will be seen how large a portion of our æsthetic gratifications depend on our sympathy with others. The hard and selfish care little for art and nothing for fiction. How should we bear to lose the pleasures which painting and sculpture, music and fiction, afford us? How even should we bear to change the pleasures given by the kindly and sympathetic art of to-day for the harsher effects of the arts of harder times when only deeds of conquest or ceremonial observances were represented in paintings and sculptures, suggested in musical strains, or recited in story or in song? What material gains, what sensual gratifications, what power, wealth, or fame, would make up (to us) for the pleasure we derive from the higher emotions? and how largely do these depend on the sympathies by which men are moved to loving care for the well-being of their fellows!

It remains lastly to be noticed that as there should be thought for others, and for the just rights and interests of others in the family, in the society with which we are directly associated, and within the race or nation, so there should be a wider altruism having regard to the rights of other races and nations. Hitherto men have scarcely at all recognized this duty. Very gradually the sense of altruistic duty passed beyond the family to the community of families, and thence still widening to the nation formed of such communities. Men learned that as personal selfishness is in the long-run opposed to the true interests of self, so family selfishness is only a degree less pernicious. The selfishness of parochialism was in turn seen to be mischievous, though it is still prevalent enough. But the selfishness of what is called patriotism—though it is as unlike true patriotism as personal selfishness is unlike due and wise self-regard—still remains as a virtue in the minds of most men, though characterized by inherent defects akin to those which belong to personal, family, and parochial selfishness. Men fail, indeed, to recognize any selfishness in undue care for what is called a man's own country—though with but vague and indefinite meaning. Nay, a blind love of country is regarded as something so directly the converse of selfishness, that Sir Walter Scott speaks of the absence of this sort of patriotism as simple selfishness. After asking if the man lives with soul so dead as never to have said to himself, "This is my own, my native land?" he goes on to say that such a man, a "wretch concentered all in self," can be swelled by no minstrel music, and is bound to go unmourned and unsung to an unhonored grave. The idea that patriotism could under any circumstances be exaggerated, and become but a widened form of selfishness, would doubtless have outraged utterly Scott's sense of the fitness of things. Yet viewing matters from the outside, and, as far as possible, independently of inbred ideas, there is nothing except its wider range to

distinguish the selfishness of exaggerated patriotism from personal or family selfishness.

That patriotic selfishness is mischievous in its effects would scarcely need showing if men were not so ready as they are to be deaf to the teachings of experience. The well-being of other nations is in the same sense essential to the well-being of our own nation as the well-being of other members of the body social is essential to our own personal well-being. The misfortunes of any nation with which our own has relations are misfortunes to our own nation, however they may be brought about, whether by internal misgovernment, by the attacks of other nations, or by our own warlike measures. There can be no doubt, for example, that the loss incurred by Germany, the victor, was only less than the loss incurred by France, the conquered, in the disastrous Franco-German War. Other nations suffered greatly, but Germany more, and France most of all. In the war with Russia, in 1854–'55, all Europe suffered. In the American civil war not only all the United States but the whole world incurred loss. It is easy for nations to blind themselves, nay, most nations are naturally blind, to the losses suffered by each through the misfortunes of others. But there can be no doubt about the actual facts. The British race would have been taught the lesson long since, if the lesson could reach the average national mind through experience—for we are suffering, have long been suffering, and long must suffer, from the energetic efforts of our "imperial" race to get the better of other races. Directly and indirectly, in loss of blood and material, in the paralysis of trade as well as in increased expenditure, our people has to pay for its imperial instincts, just as the man of overbearing, hard, and selfish nature has to pay in many ways for the gratification of his instincts imperious. There are the same reasons, based on material profit, for inculcating just and considerate dealings between peoples as there are for encouraging just and considerate dealings between man and man. But at present nations delight in proclaiming themselves selfish and overbearing; the more brutal instincts which remain dominant in nations after they have begun to die out in individuals are upheld as virtues, much as in old times many races regarded the more brutal qualities of humanity as chief among the virtues.—*Knowledge.*

THE PROBLEM OF POPULATION.

By CHARLES MORRIS.

IN passing through the open galleries of that busy ant-hill called a city, with its endless ebb and flow of human beings, intent on their various pursuits of business or pleasure, and succeeding each other in a seemingly endless procession of busy life, there is apt to rise forcibly

before our minds the vital questions of human fecundity, and of the ability of the earth to sustain its increasing multitude of human inhabitants. But in reading the statistics of this subject our interest in it redoubles. When we find men in all nations and in all ages pressing sharply on the means of subsistence, the loss by famine quickly replaced by new food for famine, the ravages of war and pestilence rapidly obliterated by new-growing populations, and apparently nothing but the pressure of sheer want and misery able to limit human fecundity, we may well question if this is to be the continued destiny of mankind, and if there is no possible limit to population within this sharp boundary of distress.

Nearly a century has elapsed since Malthus published his disheartening researches on this subject, and his conclusions yet remain only in part refuted. If it really be, as he declares, that population tends to increase in a geometrical ratio, while the food-supply increases only in an arithmetical ratio, his conclusion, that population has a constant tendency to run ahead of subsistence, seems inevitable. Fortunately, however, his hypothesis, so far, has been proved only by arguments, not by irrefutable facts. The numbers of mankind, it is true, have frequently passed the boundary which divides want from plenty. But the other requirement of the Malthusian doctrine was not, in those cases, attained. Food-production has never yet reached its limit, and the suffering so far caused by want of food might have been entirely obviated had the earth been fully cultivated. It may, however, be claimed by disciples of Malthus that this fact has nothing to do with the question, and that, when the utmost food-production has been attained, population will still press beyond it to the starvation limit. This argument we venture to dispute. The attainment of a great food-production introduces certain conditions into the problem which may give it an entirely different aspect. Such excessive production will require, for instance, a marked advance in human intelligence, and the replacement of much of the muscular labor of mankind by an active mental labor. It is our purpose to consider what effect this changed condition of the human race will have upon the increase of population. It is easy to point to modern instances in which the rapid increase of population has been checked without special exercise of the starvation influence. The population of France, for instance, has been almost stationary for many years, its increase being much below the corresponding increase of wealth in that country. Thus France furnishes a practical argument against the Malthusian hypothesis, and shows that the growth of population may decline from other causes than vice, misery, and disease.

There exist, in fact, three separate checks to the increase of population. These may be here classed as the physical, the mental, and the physiological. The first and second of these have been fully considered by writers on political economy. The third has been barely

glanced at. And yet this third may contain the true solution of the difficult problem, and through its active operation the geometrical increase of Malthus may, perhaps, be succeeded by a stationary condition of human population.

By the physical check we mean the effect of all the forces which act from outside upon the individual—such agencies as war, famine, pestilence, exposure, climatic changes, and all similar destructive influences. The mental check refers to influences proceeding from the mind of the individual. It is what is usually called the prudential check, through which individuals wisely decline to bring into the world children who must be exposed to inevitable misery, or governments restrain injudicious marriages by enactments looking to the same end. The physiological check is also internal in its origin, but not voluntary. It consists of that limit to human fecundity which is caused by employment of the organic forces in other directions.

Of these three checks to population the second only is fully under the control of the individual himself. The physical check largely arises from the action of other individuals, such as the war-making powers. It also largely flows from the hostile energies of Nature, and may, in this direction, be partly set aside by individual effort, through attention to the laws of health, and prudent avoidance of injurious conditions. The physiological check is beyond the reach of the will. It is a natural effect of human development, needs no forced restraint from marriage for its operation, and is consistent with the most natural and desirable of human relations.

Of the three checks to population here named, we will, in this paper, consider only the physiological. The others have been written upon so abundantly that there is little new to be said concerning them. It will suffice here to remark that the physical check—that which acts through the agency of famine, violence, disease, and similar influences—has ruled almost supreme in the past ages of the world, and is still vigorously active upon the great mass of mankind. The prudential check, which acts through forced desistance from marriage and child-bearing, is now actively effective in several of the more advanced European nations, probably most fully in France, and has gone far toward negativing the action of the Malthusian law. The physiological check, which we have here to consider, has also been somewhat effective in the past, but its highest influences are only now coming into play, and it promises to become an efficient and desirable agent in hindering the undue increase of human population in the future.

The principle to which we here allude has been very greatly neglected by writers on the subject of population. Those who have dealt with it have done so only cursorily, and have failed to consider it in all its bearings. It is therefore a problem that is open to further investigation. And in entering upon this inquiry it is necessary to

begin with some thoughts upon organic physiology in its general relations, as preliminary to the special results desired.

The animal frame is a material organism which is kept in activity by certain energies. These energies are constantly exhausted and constantly renewed, but their vigor at any fixed period is limited, and can not be indefinitely increased. The force received from without is variously employed within the organism. It acts successively as muscular, nervous, temperature, and reproductive energy. But being limited in quantity, if it be employed by any of these organic agencies, its use by the others is restricted or prevented. Much of the energy received is used up in alimentary processes—the pursuit, seizure, mastication, and digestion of food. Only the excess over this is available for the other organic necessities. And, if this excess force be exhaustively employed by any one of the bodily agencies, it becomes unavailable for the others.

The fact here briefly stated is one which might be illustrated by numerous instances drawn from the lower animal world. A very interesting example of its influence may be perceived in the organic conditions of the ants, and, to a lesser extent, in other insect tribes. Ants, though possessed of all the organic force agencies, do not employ them all in any one individual. The males and the fully developed females exhaust all their life-force in reproduction, with little display of muscular and none of mental vigor. The remaining members of the tribe, divided into workers and soldiers, devote all their life-force to muscular and mental labor. They are, functionally, females, but their organic energies are entirely withdrawn from the reproductive agencies, and devoted to other life-purposes. Of these two classes the workers appear to have the highest mental development. The soldiers understand the whole business of fighting, but beyond that they seem incapable, and take no part in the nest-building, the food-gathering, or any other of the ant-industries. Indeed, they are too dull or too proud to even feed themselves. They would starve unless fed by the workers or slaves. And in the occasional ant-migrations the soldiers are carried bodily by the workers, neither resisting nor aiding in the labor necessary to move their high dignities. In the workers the exercise of muscular force seems to be accompanied by a considerable employment of mental energy, since they perform many actions which appear to indicate an advanced intelligence.

This illustration from the ants might be extended to the bees, and to some other insects. We might also describe the very curious and diversified separation of function in the members of the *Siphonophoræ*, or compound polyps. But there is no occasion to multiply illustrations. If we ascend to the higher animals we find no such division of function. And yet circumstances largely govern the extent to which the organic force is applied in any one direction. But we must make here a distinction which facts yet to be described render very

evident. The exertion of muscular force, unless exhaustively employed, seems not injurious to the reproductive functions. Mental exertion, on the contrary, seems to restrict reproductive energy, even when not employed exhaustively.

But the animals below man do not employ mentality to any great extent. Their principal exertion is muscular, and this hinders reproduction only in case of the whole vigor of the animal being exhausted. If, for instance, the food-supplies of any animal tribe be diminished, or its numbers increased, a greater exercise of agility is required to satisfy its appetite. And if it depend on cunning or shrewdness to obtain food, its mental faculties must become very actively exercised. If these efforts become exhaustive, reproduction is necessarily restricted; while the young born under such circumstances are apt to be constitutionally weak, and unable to bear the strain of an excessive effort in food-getting. There is thus in this effect a strong check on population from strictly physiological causes.

The conclusion here reached applies equally to the lower orders of mankind. A diminution of food-supply must have an effect upon savages similar to its influence upon the lower animals. Excessive muscular exertion, extensive migratory movements, warlike efforts, and exercise of mental vigor in food-getting, which become more physically exhaustive the greater the difficulty in obtaining food, must act to greatly restrict reproductive energy, and to enfeeble the children who may be born during such an exhausted condition of their parents. The lack of sufficient nutriment is a correlative agency under the same conditions.

The physiological check, therefore, in this phase of its action, tends to prevent the Malthusian law from being other than an abstract possibility. Decrease in food-supply causes a decrease in food-consumers, through the exhaustion of organic energy in other directions than that of reproduction. And the new generation of consumers is constitutionally enfeebled, and unsuited to bear the sharp struggle of life, so that the population becomes diminished during the continuance of such conditions.

But the physiological check, in this form of its application, brings mankind too near the starvation limit to be at all desirable. There is, however, another mode in which it exercises itself, yielding far more promising results. For there is reason to believe that active mental labor is far more exhaustive of reproductive energy than is equally vigorous muscular exertion. Just what is the organic cause of this we shall not attempt to guess. It is possible that the brain, in its action, may exhaust some material necessary to germ-formation—perhaps phosphorus, which seems to be an element both of the sperm-cells and of the brain. But it is the visible results, rather than the organic causes, with which we are just now concerned.

It is an undoubted fact that the families of the poor are, as a rule,

larger than those of the rich. And it is equally certain that brain-workers have, ordinarily, smaller families than muscle-workers. The industrial classes of our day do not perform exhaustive labor. Nor are they usually in the habit of strong mental exercise. The physical labor they perform seems to have no limiting effect upon their procreative powers. The families of day-laborers are usually above the average in number. And it has been observed that the pioneer inhabitants of a new country are very prolific. While physical assault upon Nature is the rule, with food abundant and easily obtained, the physiological check upon increase does not seem to strongly operate. When this first severe duty is over, and men settle down to a mental assault upon Nature, their fecundity considerably decreases. The extensive families of the pioneer settlers of this country are being replaced by the small families of the active brain-workers among their posterity.

As to whether animals that depend mainly on shrewdness are less prolific than those that trust chiefly to strength and agility, we have not sufficient facts at hand to decide. Among the lower human races there is a marked chastity and infertility in the hunter and pastoral as compared with the agricultural tribes. But the former pass lives of much greater mental excitement than the latter. The steady, regular labor of the agriculturist is replaced in the nomad by rapid variations from excessive exertion to extreme inactivity, while a constant exercise of cunning and shrewdness is necessary in the rapidly fluctuating perils and difficulties of the nomadic life.

As to the relations existing between the various classes in civilized nations, it may be mentioned that the population of country districts appears, as a rule, to be more prolific than that of cities. Until within a recent period there was hardly one of the large cities of Europe that kept up its population by the natural increase of its inhabitants. Their increasing numbers were due to continual supplies from the rural districts. The much greater mental activity of civic populations as compared with those of the country is, at least, significant in this connection. If, again, we consider the higher classes in civilized nations, it at once appears that there is a constant tendency to decrease of population in these classes, and a necessity of frequent replacement from the lower grades of society. Thus there has been, in every century, a rapid thinning out of the families in the British peerage. An incessant creation of new peers has taken place, and yet they have hardly kept up their numbers, while very few of the original noble families have an existing representative. The same thing appears in the history of ancient Rome. The early noble families were almost extinct in the time of Claudian. Those created in the reigns of Cæsar and Augustus were nearly exhausted at the period of Tacitus. Malthus says that, in the town of Berne, of 487 wealthy families, 379 became extinct in two centuries. In 1623 the sovereign council was composed

of members of 112 different families, of which only 58 were in existence in a century and a half afterward.

If we consider special cases of noted men, the great generals of the world, the commanding statesmen, the distinguished scientists, the celebrated authors—all, in fact, who have become distinguished for superior mental ability—an almost universal result appears: they have either left no descendants, or their families were very small. And, for that matter, we need but to look at evidences everywhere surrounding us. We think it will be found to be a general rule that persons constantly exercised in mental labor have few or no children; those of less active minds have larger families; while the largest families belong to those who do not trouble themselves to think at all.

There is abundant reason to believe, then, that such a physiological check to population really exists; and, in its operation, it is not difficult to perceive a rich promise for the future of the human race. For it is in no sense, in its superior phase, a starvation check. Nor does it need any of the violent repression of natural desires exercised in the prudential check. At first sight, it appears as if its tendency must be to constantly place the cultured at a disadvantage in numbers as compared with the dull and ignorant. But this disadvantage is more than counterbalanced by the progress of education and the brain-incitements of modern civilization. Thus, the class of brain-workers is being continually recruited, despite its lack of fecundity, and we can see indications of an immense future augmentation of this class of the population at the expense of the unthinking, and consequently of a new barrier to the progress of population, whose efficacy is now but beginning to appear.

It is a process which must in time do away with the "starvation check" to population, and replace it with a new and far more desirable limiting principle. For when nerve-energy largely replaces muscular energy, and advanced education greatly increases the percentage of the cultured, there may be a corresponding decrease in the birth-rate, through the operation of the causes just considered. And, as human want decreases and comfort advances, the developed needs of mankind must extend the prudential check on early marriage, which is so active now in the middle classes. In this another limiting force will be brought to bear upon the increase of population.

Thus, as the sum of human wealth increases, through the exercise of intelligence in industrial operations, it will necessarily be divided among a population not increasing in an equal ratio. The average wealth of all classes of the community must increase in consequence, the necessary amount of active muscular labor be reduced, and more time be given for rest, enjoyment, or indulgence in mental culture.

The more rapidly that wealth accumulates in proportion to population, and, the more vigorously that culture forces its way downward through the community, the greater must be the effect of the pruden-

tial and physiological checks to increase of population; the final result, perhaps, being one in which the birth-rate and death-rate shall become closely allied, and a virtually stationary condition of population ensue.

We have here indications of a rich promise for the future of the human race. If the numbers of mankind become thus checked, while wealth continues to grow, and culture, with its advanced needs, becomes a general possession, the standard of desire must rise, until absolute want may no longer mean, as now, physical misery and starvation, but may mean the deprivation of what would now be considered luxuries beyond the reach of the poor. In such a case the population of the earth could never sink, as now, to press upon the sharp edge of absolute destitution. It would be too far above this limit to sway so far downward, and misery from want of food might become an obsolete tradition of the past.

PROTECTION AGAINST LIGHTNING.

I.

THE first lightning-conductor was erected by Benjamin Franklin upon his own house in Philadelphia in 1752. The invention is, therefore, now a little more than one hundred and thirty years old. Franklin was led to the investigations which resulted in its construction by the fortuitous circumstance that, about six years previously, he had been present at a lecture on electricity delivered in Boston by Dr. Spence.* In the same year—that is, in 1746—he received a present from Peter Collinson, a member of the Royal Society in London, who was also the agent of the Library Company in Philadelphia, of one of the London electric tubes, and an account of some experiments that had recently been made by Dr. Watson, Martin Folkes, Lord Charles Cavendish, Dr. Bevis, and others of their contemporaries. The idea had already suggested itself to these investigators that the luminous gleam which was elicited from glass tubes when they were rubbed in dark cellars, in performance of the frequently repeated and fashionable experiment of the day, might possibly be of a kindred nature to the lightning of the thunder-storm. In a book describing some "physico-mechanical experiments" that he had made, published in London in 1709, Francis Hawksbee remarked that the luminous flash and crackling sounds produced by rubbing amber were similar to lightning and thunder. In 1720 Stephen Gray, the pensioner of the Charterhouse, so celebrated for his electrical investigations, boldly and uncompromisingly affirmed that, "if great things might be com-

* It is, perhaps, worthy of remark that, in this lecture, the experiments were made by the primitive instrumentality of a glass rod and silk pocket-handkerchief.

pared with small," the light and sound called forth when glass rods were rubbed were of the same nature as lightning and thunder. Franklin, from the time when the electrical experiments came under his notice, enthusiastically adopted this view. In a letter written to a friend in 1749, he very clearly expressed his reasons for this belief. In this communication he insisted upon the facts that the electric spark gives light like lightning; that the luminous discharge follows a similar crooked track; that this discharge is swift in its motion, is conducted by metals, is accompanied by an explosion when it escapes, rends bodies that it passes through, destroys animal life, melts metals, sets fire to inflammable substances, and causes a smell of sulphur—all of which attributes seemed to him to point to the identity of the phenomena. He also observed that the electric discharge was attracted by points, and stated that he was bent upon ascertaining whether lightning had not the same tendency. In the autumn of the following year he wrote to Mr. Collinson to say that he had satisfied himself in this particular; that he was entirely convinced of the identity of the so-called electricity with lightning; that he believed the damage done by lightning descending from the clouds to the earth might be altogether prevented by placing iron rods, with sharp points, upon the summits of buildings; that he intended to test experimentally the soundness of his belief in that matter; and that he hoped other persons would assist him in his labors by following his example. This was virtually the definite forecast of the conductor which Franklin attached to his house in 1752.

In the mean time the suggestion that buildings might be protected from lightning by the use of iron rods with sharp points was incidentally communicated by Mr. Collinson to the editor of the "Gentleman's Magazine" in London, who, at once perceiving the practical importance of the hint, offered to print an account of Franklin's views in the form of a pamphlet. This offer was accepted, and, in the month of May, 1751, a pamphlet was published in London, entitled "New Experiments and Observations on Electricity made at Philadelphia, in America, by Benjamin Franklin." The pamphlet was not very warmly received in England, but it was enthusiastically welcomed and appreciated in France. Count de Buffon had it translated into French, and the translation appeared in Paris within four months of the publication of the original pamphlet in England. It was soon afterward translated into German, Italian, and Latin. The attention of scientific men in Paris was quickly drawn to the method of defense proposed by Franklin, and M. Dalibard, a man of some wealth, undertook to erect the apparatus at his country residence at Marly-la-Ville, some eighteen miles from Paris. The situation of the house was considered to be eminently favorable for the purpose, as the building stood some four hundred feet above the sea. A lofty wooden scaffold, supporting an iron rod an inch in diameter and eighty feet long, was erected in the

garden. The rod was finished at the top by a sharp point of bronzed steel, and it terminated at the bottom, five feet above the ground, in a smaller horizontal rod, which ran to a table in a kind of sentry-box, furnished with electrical apparatus. On May 10th, when M. Dalibard was himself absent in Paris, the apparatus having been left temporarily in the charge of an old dragoon named Coiffier, a violent storm drifted over the place, and the old dragoon, who was duly instructed for the emergency, went into the sentry-box and presented a metal key, partly covered with silk, to the termination of the rod, and saw a stream of fire burst forth between the rod and the key. The old man sent for the Prior of Marly, who dwelt close by, to witness and confirm his observation, and then started on horseback to Paris, to carry to his master the news of what had occurred. Three days afterward, that is, on May 13, 1752, M. Dalibard communicated his own account of the incident to a meeting of the Académie des Sciences, and announced that Franklin's views of the identity of the fire of the storm-cloud with that of the electrical spark had been thus definitely established.

Before the success of M. Dalibard's experiment could be reported in America, however, Franklin had secured his own proof of the identity by the memorable experiment with the kite, so well known to the scientific world. He was anxiously waiting for the erection of the first steeple in Philadelphia for the opportunity which this would afford him for the support of a lofty iron rod, when the happy idea occurred to him to try, in the mean time, upon some suitable occasion, whether he could not contrive to hold up a lightning-conductor toward a storm-cloud by means of a kite. On the evening of July 4th, that is, fifty-two days after the experiment of M. Dalibard, his kite was raised during a thunder-storm, and, with the help of his son, he drew electric sparks from the rain-saturated string, as the two stood in the shelter of an old cow-shed in the outskirts of Philadelphia. He held the kite by a silken cord that was attached to a key at the bottom of the string, and with this arrangement he charged and discharged an ordinary Leyden-jar several times in succession. Franklin at first not unnaturally conceived that he had actually drawn the lightning down from the storm-cloud. He was, however, no doubt mistaken in this. The storm-cloud had inductively excited the neighboring surface of the earth, and what Franklin saw was the electric stream escaping out through the wet string toward the storm-cloud to relieve the tension set up by this induction. It was in the summer of the same year, after the performance of this world-renowned experiment with the kite, that Franklin attached to his house a lightning-conductor, which was composed of an iron rod, having a sharp steel point projecting seven or eight feet above the roof, and with its lower end plunged about five feet into the ground.

As a matter of course, the new doctrine of Franklin and his allies

was not received without considerable opposition. A sharp shock of an earthquake having been experienced in Massachusetts in 1755, this was forthwith attributed to the evil influences of Franklin's lightning-rods. A Boston clergyman preached against them in 1770 as "impious contrivances to prevent the execution of the wrath of Heaven." Even as late as 1826, an engineer in the employment of the British Government recommended that all lightning-rods should be removed from public buildings as dangerous expedients, and in 1838 the Governor-General and Council of the East India Company ordered that all lightning-rods should be removed from public buildings, arsenals, and powder-magazines throughout India, and only became reconciled to their restoration after a large magazine and corning-house, not furnished with a conductor, had been blown up during a storm.

Franklin was so much in earnest in reference to his invention that he sent a friend at his own charge through the principal towns of the New England Colonies to make known the powers and virtues of the lightning-rod. In the "Poor Richard" for 1758, a kind of almanac or manual which he was at that time publishing, he gave specific instructions for the erection of his rods. The second conductor which he himself constructed was placed upon the house of Mr. West, a wealthy merchant of Philadelphia. A few months after this had been erected a storm burst over the town, and a flash of lightning was seen to strike the point of the conductor, and to spread itself out as a sheet of flame at its base. It was afterward found that about two inches and a half of the brass point had been dissipated into the air, and that immediately beneath the metal was melted into the form of an irregular blunt cap. The house, nevertheless, was quite uninjured. The sheet of flame seen at the base of the conductor Franklin correctly ascribed to the ground having been very dry, and to there not having been a sufficiently capacious earth contact under those circumstances. He nevertheless shrewdly, and quite justifiably, assumed that in this case Nature had itself pronounced an unmistakable verdict in favor of his invention.

The controversy concerning the efficacy of lightning-rods continued to agitate the councils of scientific men, notwithstanding this memorable demonstration of their efficiency; but, upon the whole, the new doctrines made their way into the confidence of the intelligent classes of the community. The most important circumstance in connection with the early fortunes of the invention, perhaps, was the admirable series of reports and instructions which were issued by the French Government between the years 1823 and 1867, and to which Mr. Anderson now once again, and not superfluously, draws public attention in his recent pamphlet entitled "Information about Lightning-Conductors issued by the Academy of Sciences of France." The first of these reports was drawn up in 1823 by Gay-Lussac, the discoverer of the law of the expansibility of gases, the companion of Humboldt, and the

distinguished meteorologist who first ascended four miles and a half into the air in a balloon. The second and the third were prepared in 1854, and in 1867, by M. Pouillet, the director of the Conservatoire des Arts et Métiers in Paris, and the author of a well-known work on the elements of experimental physics and meteorology, which has been translated into many languages. These reports, although drawn up by an individual, were the results of the deliberations and experiments of a considerable number of scientific men, acting as a commission, and comprising among them such distinguished names as those of Poisson, Fresnel, Becquerel, Duhamel, Fizeau, and Regnault. In the first of these reports, that, namely, of Gay-Lussac, which was adopted by the Academy of Sciences on April 23, 1823, it was premised as a kind of axiom that there are no bodies which do not offer some resistance to the transmission of electricity, and that conductors of small diameter offer more resistance than those which are of the same composition and of larger size. The electrical state was conceived in these investigations as consisting of some kind of matter—as depending upon molecules which are mutually repulsive, and which therefore tend to separate and disperse themselves through space, and which are only retained upon the surface of solid bodies by the pressure of the atmosphere. When the electric matter escapes, it seeks the earth under its tendency to diffuse itself over the most capacious conductors it can find, selecting the most perfect of them that are within its reach, but dividing itself in proportion to their individual capacities of accommodation, when several conductors of unequal power are open to its transmission. A storm-cloud, hovering above in the air, attracts toward the nearer part of the terrestrial surface an electrical matter of a contrary nature to its own, and drives back into the ground an electrical matter of the same nature as its own. Each prominent part of the ground is therefore, for the time, in a state of electrical tension during the presence of a neighboring storm-cloud, and becomes a center of attraction toward which the lightning inclines. When the prominent object is in good connection with the ground, its electrical matter may shoot forth toward that of the cloud, and make a path between it and the cloud. If the prominent body projects as a sharp point toward the cloud, the escape of the electric matter from it to the cloud becomes very rapid, and the lightning strikes to it from the cloud, from a greater distance. It was further conceived that a good conductor protected from any violent discharge a circular space whose radius was twice the height of the rod. An iron bar three quarters of an inch square was taken to be of sufficient dimensions for the construction of a conductor, because no instance had been known of a rod a little in excess of half an inch in diameter having ever been fused or raised to a red heat by lightning. Even small rods or wires that were dispersed by the passage of lightning had served to convey it to the ground, and had protected surrounding objects from single strokes. Trees were

recognized as dangerous to animals taking shelter near their trunks, because they do not convey a lightning-discharge with sufficient rapidity to the ground, and because they are worse conductors themselves than animal bodies. But the discharge will not in any case leave a good conductor, well connected with the ground, to strike a living animal placed near its course. The terminal rod of a conductor was ordered to be two and a half inches square at its base, and to taper to a height of twenty or thirty feet above the building, with a needle of platinum, or of copper and silver alloy, at its top. The base of the rod was to be plunged into the ground, and then led away from the building for fifteen feet, being finally turned down into a hole or well fifteen feet deep, and then divided into root-like ramifications, the whole being well packed round with charcoal to protect the metal from rust. In a dry soil the earth contact was to be twice the length of the one which was deemed sufficient in a wet one. It was above all things insisted upon that too great precautions could not be taken to give the lightning a ready passage into the ground, as it was chiefly upon the freedom of this passage that the efficacy of the conductor must depend. A conductor with insufficient earth contact was stigmatized as being not only inefficacious, but dangerous, because it would attract the lightning without being able to convey it to the ground.

It was further asserted in this most comprehensive and notable report that an experience of fifty years had proved buildings to be effectually protected when good conductors were placed on them. In the United States a number of conductors had been known to have been struck, but in not more than two of these cases had the buildings themselves suffered any damage. It was generally assumed, from the data then at command, that buildings which were protected by lightning-rods were not more likely to have the discharge brought down in their neighborhood on account of the presence of the rods, and it was also held that, even if they were open to such a liability, this could be of no practicable moment, because the power of a conductor to attract the lightning more frequently would, of necessity, also involve the capacity to convey it more freely to the ground. Points were spoken of as undoubtedly tending to neutralize the tension of a charged cloud. Dr. Rittenhouse was referred to as having observed in Philadelphia that the points of lightning-conductors were frequently blunted by fusion without the houses to which they were attached having been in any way injured.

The views advocated in this early code of instructions have been dwelt upon it some detail, in order that it may be seen how effectively this document laid down the broad principles of defense which are acted upon even at the present day. This instruction, after it had been stamped with the approval of the Academy of Sciences, became a sort of popular manual under the weight of this sanction. The Government gave force to the instruction by providing that it should

have effect in reference to all public buildings and churches. The report also became the chief authority on the subject in most foreign lands. It likewise served the useful purpose of weakening the opposition, which still endeavored to maintain that disastrous explosions were caused by conductors, and furnished clear and precise rules for construction that were intelligible to ordinary workmen.

In the year 1854 iron was much more generally used in buildings than it had been at an earlier date, and some additional knowledge of the conditions and laws of electrical action had been acquired. The Academy, on this account, thought it well to request the Section of Physics to reconsider the lightning-rod instruction of 1823. This led to the first report, which was prepared by M. Pouillet, adopted by the Academy of Sciences on March 5, 1855, and immediately afterward issued by the Government as an additional instruction. In this document it was held that the large masses of iron employed in buildings certainly serve to attract the lightning. If two buildings of an equal size were similarly placed, the one being exclusively of stone and wood, and the other having large masses of metal in its construction, the lightning would certainly strike the latter and avoid the former, just as, when a ball of metal and a ball of wood are presented together toward a charged prime conductor of an electrical machine, it is always the former, and never the latter, which receives the spark. A dry soil, it was pointed out, does not attract the lightning. But, if, under such a soil, there occur at some depth large masses of metal, or accumulations of water, the lightning would explode through the dry earth, splitting it up as a coat of varnish is pierced by an electric spark. The line of lightning-discharge is always marked out for it beforehand, in conformity with the law of electric tension, beginning at the same instant at both the extremities of the track. The objects which are most liable to strokes of lightning are good conductors that project farthest over toward the clouds.

In the report of 1855 the occasion was used to draw attention to some instructive instances of the mechanical effects of lightning-discharges which had taken place upon the open sea. In 1827 the packet-boat New York, not at the time carrying a conductor, was struck during its passage across the ocean, and a leaden pipe, three inches in diameter and one inch thick, was fused where the discharge escaped into the sea. A chain of iron wire, one quarter of an inch in diameter and one hundred and thirty feet long, having been then hoisted up on one of the masts and trailed in the sea, was struck by a second discharge, and scattered into molten molecules and broken fragments, the bridge being set on fire, although at the time covered by a sheet of hail and a deluge of rain. The Jupiter, in the North Sea fleet, in 1854, carrying a chain of several strands of fortieth-of-an-inch brass wire, two hundred and sixty feet long, hung from the mainmast-head, and trailing seven feet into the sea, was struck, and had the chain

scattered into thousands of fragments, without any damage being done to the vessel itself. A Turkish ship cruising near at the time, with a chain from the masthead which did not reach into the sea, had a hole like that which would have been made by a cannon-shot pierced through the hull near the water-line. The inference was drawn from these cases that chains, and especially small chains, were not trustworthy for the purpose of conducting discharges of lightning. The mechanical violence sustained was perceived to be due to the circumstance that the conductors provided were of a bad principle of construction. They were at the least from nine to ten times too small. Conductors provided by engineering art are intended to be struck, but struck in such a manner as to govern the lightning, and to render the heaviest strokes harmless. No case had been known of a continuous iron rod, three quarters of an inch in diameter, or with a sectional area of one and a quarter square inch, having been structurally injured. The cases alluded to were held to demonstrate that conductors must have a sufficient size and thickness of metal, and must be continuous and without defect from end to end. It was definitely settled that, in accordance with these requirements, a square iron rod used as a defense against lightning should have, at least, a diameter of nine sixteenths of an inch, and that a round rod should have a diameter of ten sixteenths of an inch.

Some modification was also made in this instruction in reference to air-terminals. It was considered that a blunt point, fashioned like the apex of a cone subtending an angle of thirty degrees, would be less liable to fusion than a sharper and more attenuated point, and that therefore it should be adopted for the upper terminal, although it might, perhaps, not exert altogether so satisfactory a neutralizing influence. The area protected by a conductor was now considered not to be so definite and certain as it was previously held to be. It was recognized that it would be less in the case of a building with a metal roof, for instance, than in other circumstances. The earth contact, it was remarked, could not be looked upon as efficacious unless it were made, through the instrumentality of sheets of water, at least as large as the area of the storm-cloud, and access to such sheets must be secured by boring both in the direction of the surface moisture and in that of the deeper soil. Chains of red copper with a square section of three eighths of an inch, and weighing a pound and three quarters per yard, were recommended for ships. Such were the principal suggestions of a practical kind that were submitted in this report. In all other particulars the provisions of the earlier instructions were substantially approved and confirmed. There was, however, one incidental remark contained in this excellent report which is deserving of the highest commendation and approval on account of its practical wisdom. This emphasized the necessity for continued and minute observation and study of the effects of thunder-storms, with a view

alike to ascertain what it is that lightning spares, as well as what it strikes. It is of the utmost importance, for the advance of man's knowledge in this branch of physical investigation, that all instances of injury from lightning should be immediately examined and tested, and that all facts ascertained should be accurately described and placed upon record.

In the year 1866 the Minister of War in France became doubtful in regard to the measures which were then taken to secure powder-magazines against accident from lightning, and in consequence once again brought the matter formally under the consideration of the Academy of Sciences. It was this action of the minister which led to the third report, also drawn up by M. Pouillet, adopted by the Academy in the beginning of 1867, and shortly afterward issued under the authority of the French Government. In this report the best method of making joints in a conductor by overlapping, riveting, and soldering the contiguous ends, was pointed out, and it was urged that the underground continuation of the rod should be carried on to an adequately moist place, even if miles had to be traversed for the purpose. The increase in the number of air-terminals and the connecting them together were deemed of more consequence than the increasing the height of a smaller number. Secondary terminals were advised for every additional length of thirty-three yards of roof. The expansion of rods by heat was provided for by inserting free semicircular bands of red copper at suitable intervals, four inches of addition to the length being allowed for in every hundred yards of rod.

The example set by France in the preparation of these reports was followed for the first time in England by the appointment of a Naval Commission in 1839 to inquire into the protection of the vessels of the Royal Navy. This commission was formed in consequence of the public attention which had been drawn to the matter by Snow Harris, who stated that, within the forty years that ended in 1832, two hundred and fifty vessels had been more or less seriously injured by lightning. The commission somewhat haltingly reported that there was no harm in lightning-conductors, and that it thought the system of protection might be tried. Snow Harris thereupon introduced the plan of nailing a double set of overlapping strips of copper along the masts. After the adoption of this method the conductors were struck by lightning in several instances, but in no case did the vessels suffer any damage. This excellent system was only superseded in the end by the natural result of the introduction of iron vessels, which made the ships themselves efficient conductors in virtue of the principle of their construction. The original idea of Snow Harris was, indeed, to bring the general structure requiring defense as nearly as possible into the same non-resisting state that it would have if entirely composed of metal. He was knighted for his services in 1847, and in 1855 was employed to design the protection of the then new Houses of Parliament at West-

minster, which he carried out by a modification of the plan that he had matured for the protection of the vessels of the Royal Navy. Two-inch tubes of copper, connected by solid screw plugs and coupling pieces, were affixed to all the more elevated portions of the building. The sum of £2,314 provided for the execution of this work was memorable as being the first grant made by the English Parliament for the protection of a public building against lightning.

About ten years after the erection of the lightning-conductors upon the Houses of Parliament at Westminster, it was found to be desirable to provide a similar protection for the magnificent old Hôtel de Ville at Brussels, in consequence of some damage having occurred to the principal tower of the building during a thunder-storm. The communal administration of the city had recourse to the Académie Royale des Sciences for advice in the emergency, and a commission, consisting of M. Duprez, M. Liagre, and Professor Melsens, was appointed to give a careful consideration to the matter. Professor Melsens visited Plymouth and London, to consult with Sir W. Snow Harris, and to examine the plan of defense which had been adopted for the Houses of Parliament. Shortly afterward the commission at Brussels submitted to the communal administration the famous plan of lightning-defense which has since been carried out at the Hôtel de Ville, and which has been described in the minutest detail in an illustrated work entitled "Description détaillée des Paratonnerers établis sur l'Hôtel de Ville de Bruxelles," and printed in 1865, in explanation of his views, by Professor Melsens himself.

Professor Melsens's method of defense differs in one important particular from the measures which had been recommended in the Paris instructions, and which have been most generally adopted in England. He had for some time been inclined to advocate the use of numerous rods of small size, rather than one dominant rod of more ample dimensions, whenever large buildings with numerous projecting pinnacles and gables were concerned. His view virtually is that the aim in such cases should be to throw a sort of metallic net broadcast over the building, with salient points carried up into the air at all projecting parts of the structure, and with numerous rootlets plunging down into the conducting mass of the earth beneath; and he contrived an experiment which he was in the habit of exhibiting to his visitors at the laboratory in l'École de Médecine Vétérinaire de l'État, which certainly went very far to justify the position he had taken up. He prepared a spherical case or cage of stout iron wire, and, having inclosed a small bird in this cage, he passed electric shocks through it from a battery of fifteen very large Leyden-jars, without causing either injury or inconvenience to the bird. A couple of little feathered pensioners were maintained at the laboratory for the performance of this experiment, and were subjected to the ordeal a considerable number of times, and there is no doubt could be subjected to it for any number of times,

without the remotest chance that they would ever be touched by the terrific discharges that were flashed through the walls of their prison-cell in such close propinquity to them. What happened in the case of the birds in this experiment assuredly would happen also in the case of any building that was encaged in metallic rods in a similar way. No demonstration of a mere physical fact could possibly be more absolute or more complete.

The Hôtel de Ville at Brussels is a large mediæval building, inclosing in its center an open quadrangular court, and surmounted in the middle of its principal face by an elaborately pinnacled tower, 297 feet high, with a gilt statue of St. Michael at the top, standing upon a prostrate dragon and flourishing a drawn sword above his head. There are four galleries on the spire beneath the statue, and there are also six spire-crowned subordinate turrets, and three parapeted gables projecting above the roof from other parts of the building. The statue of the saint is reared upon a lead-covered cupola or platform, and Professor Melsens determined that the point of its sword should serve as the culminant point of his system of lightning-rods; but he also took the precaution of very largely re-enforcing this highest terminal by surrounding the base of the lead-covered platform at the feet of the statue with a *chevaux-de-frise* of outwardly and upwardly branching rods, constituting a radiant circle of tufted points or aigrettes. There were altogether forty-eight of these points projecting round the feet of the statue to a distance of eight feet in all directions. From these radiating aigrettes, and from the statue standing above, a series of eight iron rods were carried down along the face of the tower and the slope of the roof, through an entire length of 310 feet, to the interior court-yard. But as these rods descended along the perpendicular face of the building they were joined by other similar rods from the various subordinate turrets, pinnacles, gables, and ridges, which all had their own systems of terminal points rising up toward the sky. There were altogether 426 points projecting up from the building. An observer looking down from one of the elevated galleries of the spire took in at a glance quite a little forest of spikes bristling up into the air, which were all in direct metallic contact with the main stems of the conductors.

An even more ample provision was made for the connection of this system of conductors with the ground. The vertical rods were first collected into an iron box fixed about a yard above the ground in the inner court, and filled with molten zinc so as to unite the whole into one continuous block of metal. From the hollow of this box twenty-four iron rods, two fifths of an inch in diameter, issued, and of these a third part was carried to an iron cylinder sunk in a well, another third was connected with the iron water-mains of the town, and the remaining third was put into communication in a similar way with the gas-mains. Professor Melsens estimated that the earth contact which

was established by this threefold distribution amounted altogether to 333,000 square yards of conducting communication. Iron rods were used in preference to copper in this construction on account of the cost which would have been entailed if copper had been employed for so extensive a work, and also because Professor Melsens had satisfied himself that iron has more tenacity and power of cohesion than copper when exposed to the disintegrating strain of powerful discharges of electricity. He devised a very pretty experimental proof of this, in which the discharge of a large battery of Leyden-jars was passed through a fine wire of equal dimensions throughout, but of which one half was composed of copper and the other half of iron. The iron portion was converted into a beaded, but still unbroken, strand by the discharge, but the copper part was scattered into a black impalpable powder. It is scarcely too much to say that the Hôtel de Ville at Brussels at the present day, with its lofty aigrette-defended tower, its forest of points, its net-work of rods, and its widely ramifying earth-roots, is, as far as danger from lightning is concerned, one of the best protected buildings in the world. It may safely be affirmed that it is quite as hard for the lightning to get mischievously at this building, as it is for the discharge of the Leyden battery to get at Professor Melsens's birds when they are inclosed in their iron cage.* In the heaviest of storms Professor Melsens travels about within the meshes of his system of conductors, to investigate their behavior, with the most perfect *sang-froid* and confidence. In 1866 Professor Melsens examined with great care the transmitting capacity of his system of conductors at the Hôtel de Ville, and in this final investigation he employed all the various means that are now at the command of science. He used continuous currents, instantaneous discharges, sparks from the electrical machine, from powerful batteries, and from a large Ruhmkorff coil, and with all he found that the conductibility of his system was practically perfect.

One of the grounds upon which Professor Melsens adopts his system of multiple rods is the circumstance that an electrical discharge diffuses itself through all the branches of a multifold conductor in proportion to the resistance which is offered by each part, and that it does not all concentrate itself into the shortest and most open path. He has devised some very ingenious experiments for proving this position, and has been able to show the sixty-thousandth part of a discharge passing by a very narrow and roundabout path, when a broad and direct one was open, and traversed by the larger proportions of the discharge. He brought this part of his subject under the notice of the Academy of Sciences of Belgium in a special note, which was printed in their "Bulletins" in 1875.—*Edinburgh Review.*

* M. de Fonvielle says of this plan of defense that Professor Melsens does not leave the lightning a gap that it can get through.

CHINESE CORONERS' INQUESTS.

THE method of conducting coroners' inquests in China seems admirably adapted to facilitate the escape of criminals. The feeling of the country is abhorrent to dissections, and magistrates, consequently, find the prosecution of their inquiries attended with great embarrassments, unless the case is of the plainest character. The law-makers, however, have always, from the earliest times, recognized the importance of human life by directing that an inquest be made in every case of sudden death. A number of books have been prepared, containing the instructions needed by the magistrate in the performance of this part of his duties. The best known of these collections was published in the thirteenth century, by the direction of the officers of the Bureau of Penalties, and is a kind of official manual for the inquiring magistrate. It is called the "Se Yen Luh," or treatise on the redress of wrongs. In it is expounded the whole system of legal medicine in use among the Chinese. A few extracts from it will be of interest.

The first advice given in the "Se Yen Luh" is that the magistrate must be sure he has a dead body before he issues his order for the inquest. The reason given to make this advice seem pertinent is hardly less curious than the advice itself. "It sometimes happens," says the manual, "that unscrupulous sharpers demand an inquest on an imaginary deceased for the sole purpose of extorting money from the person they will denounce as the author of the death; and the latter, in fear of falling into the claws of the law, readily pays all that is required of him, in order to arrest the process." The officer then, having assured himself that there is a real case, goes to the spot, taking with him a good provision of onions, red pepper, white plums, and vinegar, articles that he will almost certainly have use for. If death has taken place recently, the first step is to examine the top of the head, behind the ears, the throat, and other vital parts, for marks of a sharp instrument. If this examination does not reveal the cause of death, the friends and neighbors of the deceased are questioned. An attentive examination is then made of the wounds.

"A sure means of fixing the date of a wound may be found by noticing the color of the bone that has been attacked. If the wound is recent and slight, the bone will be red; if old and severe, the color will be dark blue. It is, however, necessary to be assured that the color is real, and has not been applied so as to square with the deposition of the relatives. A red color may be given to a bone by staining it with a composition of saffron, pine-wood, black plums, alum, and boiling vinegar; and green alum or gall-nuts mixed with vinegar will give a dark-blue or black tint; but the counterfeit is generally betrayed by the absence of luster. A false wound may also be made on a body with bamboo-coals, but such wounds are always of little depth

and soft. If birch-bark has been used for the burning, the flesh is black and soft, and the edges of the wound are livid. Burning with paper produces a wound like a fist-blow; but a red and burned spot may be remarked around the wound, while the flesh within appears yellowish and tumefied, but without consistence. A true wound can also be recognized by the clear color of the surrounding flesh. The edges of the wound resemble a kind of rainbow, something like rain seen at a distance, like clouds with a vague and indistinct aspect."

After having thus defined the characteristics of a wound, and the means of exposing every kind of deception, the manual passes to the consideration of the motives for crime. "Murders," it says, "are rarely premeditated; they are sometimes the consequence of intoxication. The magistrate," it continues, "should remember that the relatives of a wounded man may have an interest in dispatching him, so that they may demand a more considerable indemnity from the murderer. He must also inform himself, in the case of a man who was severely wounded in a brawl, whether he was honestly taken care of. In case of death, examine the body carefully from head to foot; see whether the ears have been pulled and torn, whether the nostrils have been hurt, whether the lips are open or closed, count the teeth, inspect the cheeks, carefully feel the limbs to the finger-nails and toe-nails. If the coroner can not find a visible mark of a wound, he should pour on the part vinegar with its dregs, and then put a piece of oiled, transparent cloth between the sun and the body, and look carefully. If nothing appears, let him make another trial, with powdered white plums added to the vinegar. If this, too, fails, he should prepare a cake of white plums, red pepper, onions, salt, and vinegar, and apply it boiling hot on the part of the body where the wound ought to be. An attentive examination having been made of the body, and the marks of wounds on the skin, their shape, size, and position having been noted, death should be attributed to the wound that is found in the most vulnerable spot."

It is one of the curious features of this system that, if the death is due to a blow on the lower part of the abdomen, a clew to it may be obtained from the state of the roots of the teeth in men and of the gums in women. When the inquest is held over a body in so advanced a state of decomposition that nothing is left of it but the bones, a clear day is chosen, and the bones, after having been exposed to the vapor of hot vinegar, are examined through a red and transparent cloth. The blood having been coagulated in the wounded parts of the bones, they will be brought out, and the marks—red, dark blue, or black, as the case may be—will be made visible. A long and dark mark indicates a blow made by the arm; a round mark, a blow of the fist; a smaller mark, a kick. Extravasation of blood in the bone indicates a wound made before death. If doubts exist as to the identity of the remains, a son or grandson of the deceased is required to shed

some of his blood upon it. If there is relationship, the blood will penetrate the bone, otherwise it will not. This kind of test may be compared with the ancient custom of barbarous people based upon the belief that the blood of relatives poured into the same vessel will mix, while that of strangers will remain separate. A like custom also is used in China to prove in court contested relationships; but the officer must be particularly careful that no salt or vinegar is put into the vessel, lest those substances should promote a mixture of the blood. It is believed to have been shown by experiment that men slain with a knife die with the mouth and eyes open and the hands closed, and that their skin and muscles are drawn up. If the victim has been decapitated, the muscles are tense, the skin is flabby, and the shoulders are drawn up. These features are not found when the decapitation has taken place after death. It is very important to discriminate between the effects of wounds made before or after death, for accomplished murderers seek to give their crime the appearance of a suicide.

The general aspect of the body is relied upon to give an evident indication of the state of mind in which a suicide was committed. If the teeth are clinched and the eyes are partly open, the act was done in a fit of violent passion; if the eyes are shut, the mouth open, and the teeth not clinched, the case was one of suppressed anger. If fear of punishment induced the suicide, the eyes and the mouth will be closed, and the body will have an air of repose, "for the unfortunate one regarded death as the end of his journey, as the term of rest that should disengage him from the responsibilities of life." The hands of a suicide continue soft for some time, and after a day or two the skin draws up—symptoms that are not observed in cases of murder.

In case of strangulation, which is very frequent, it is the officer's duty to inform himself with especial particularity respecting the exact position of the body, the signs on the neck, the existence or absence of the mark of the rope, the expression of the face, and a thousand other details.

The directions to be observed in cases of drowning are, on the whole, sensible, but the habit of generalizing here also leads to some strange conclusions. Thus, it has been discovered that bodies require a longer time to come to the surface of the water in the winter and the beginning of the spring than at other seasons.

With no aid from dissection, the inquests in cases of poison are, of course, very incomplete. The most usual test is to introduce into the mouth a silver needle that has been dipped in a decoction of *Gleditschia sinensis*. If, after a certain time, the needle receives a blackish tint that resists washing, poisoning is concluded to have been the cause of death. Sometimes a handful of rice is put into the mouth of the deceased and then given to a fowl, and the effect upon the bird of eating it is noticed.—*Translated for the Popular Science Monthly from the Revue Scientifique.*

SKETCH OF PROFESSOR J. P. LESLEY.

THE subject of this sketch, Professor J. P. LESLEY, this year President of the American Association for the Advancement of Science, was born in Philadelphia, September 17, 1819. He is of Scotch extraction, his grandfather, Peter Lesley, having emigrated from Aberdeenshire in Scotland. From his sixth to his twelfth year he was under the instruction of William Tucker, and showed a marked predilection for mathematics and geography. His father, a cabinet-maker, was an accurate draughtsman and an intelligent lover of architecture, and that he was in advance of his age in the matter of education is shown by the fact that he placed the pencil in his children's hands before they could write, and daily exercised them during the dinner-hour in the precise use of language for describing places and things, while obliging them to test the accuracy of their descriptions by drawings and sketches, which he mercilessly criticised. A good foundation was thus laid for those logical, linguistic, and artistic pursuits which young Lesley followed up throughout his academical years, and at the University of Pennsylvania, from which he graduated in 1838. The acquisition of French and German, music, painting, and the construction of toy machinery of all kinds in his father's workshop, were his recreations out of school-hours, and led him afterward into the ardent study of the classical and Oriental languages, and finally to that of the Egyptian hieroglyphics, those fossils of comparative philology, while occupied with the mechanical problems of geology, to which subject his life has been mainly devoted. From 1839 to 1841 Mr. Lesley was engaged on the Geological Survey of the State of Pennsylvania, under Professor Henry D. Rogers. Early interested in religious subjects, in the autumn of 1841 he entered the theological seminary at Princeton, New Jersey, and in 1844 was licensed as a minister by the Presbytery of Philadelphia. He devoted himself for a year or two to religious teaching among the German population of Pennsylvania, and in 1847 became the regular pastor of a Congregational church in Milton, Massachusetts; but his theological views soon underwent such expansion that he left the pulpit and settled in Philadelphia, to devote himself to work in the field of science. He was married, in 1849, to Miss Susan Lyman, of Northampton, Massachusetts.

In the spring of 1844 he sailed for Europe, and walked with knapsack and blouse through the western and southern provinces of France, through Savoy, Switzerland, and Germany to Halle, where he attended the lectures of Tholuck, Erdmann, Leo, and Ulrici, and returned home in the spring of 1845. In 1863 he was sent by the President of the Pennsylvania Railroad to examine the methods of hardening the surface of rails, and to report on the success of Bessemer's invention. In

the course of this journey he visited all the iron-works where flasks had been erected in England, Belgium, the south and west of France, and in Austria. In the autumn of 1866 he sailed for Brest, by the order of his physician, and, traveling through Italy, returned to perform his duties as United States Commissioner at the opening of the Paris Exposition of 1867. After struggling with a painful illness three months, he walked through the Vosges Mountains, and remained the rest of the season at Vevay in Switzerland, and then went to Egypt as the guest of Charles Hale, the United States consul-general at that time, with whom he went up the river to the first cataract in one of the viceroy's yachts, returning to Italy, England, and the United States in the spring of 1868, but abstaining from all serious business until the end of that year.

His health slowly improved, but four years elapsed before he could do an ordinary day's work; and it has been his habit ever since to seek relaxation from business, when too long continued, by short trips to Europe. Such were made in 1872, 1874, 1876, 1878, 1880, 1882, and 1884, in each case remaining abroad only two or three weeks.

In 1872 Mr. Lesley was appointed Professor of Geology and Dean of the Faculty to the newly established scientific department of the University of Pennsylvania, and in 1874 he was made chief geologist of Pennsylvania under a new act providing for a complete geological resurvey of that State. He had, in 1842, constructed the State geological map and sections for Pennsylvania, and in 1846–'47 revised them and prepared the drawings and a large part of the text of the subsequently published report on the geology of that State. His work as a geologist has been more especially devoted to the coal formations of North America, and he is regarded as a chief authority on all questions connected therewith. His "Manual of Coal and its Topography" (1856) is esteemed alike for its classification of the Appalachian coal strata and for its illustrations of topographical geology. Most of Professor Lesley's personal field-work remains unpublished, such as his elaborate survey of the Cape Breton coal-fields in 1862–'63; his topographical and geological survey of the Broad Top coal-field, which occupied two years; his contoured map of the Kishkaminitas and Loyalhanna country in Western Pennsylvania, ordered by the Pennsylvania Railroad Company, which also occupied two years; his survey of the Tennessee coal-fields west of Knoxville, etc.

Abstracts from his reports of surveys of the iron-ore deposits of Huntingdon and Centre Counties, and of Cumberland and Franklin Counties, Pennsylvania; of the titaniferous iron-ore range of North Carolina; of the Embreeville district in East Tennessee; of the geology of Tazewell, Russell, and Wise Counties in Virginia; of coal, iron, and petroleum districts in Western Pennsylvania; and of the surface petroleums of the Sandy River country in Kentucky—were published, with maps and woodcuts, in the "Proceedings of the American

Philosophical Society" under various dates. During the last ten years his official duties as director of the State survey, involving the publication of about seventy volumes of reports, have prevented in a great measure his personal work as a geologist, and he has published nothing over his own name except prefaces and notes to these reports. But a large number of his geological papers, as above referred to, together with various essays on philological and antiquarian subjects, will be found in the "Proceedings of the American Philosophical Society."

Professor Lesley was for several years Secretary to the American Iron Association, and he has also for many years been Secretary and Librarian of the American Philosophical Society. Although a hard worker in science, he is a man of varied intellectual accomplishments, of a philosophical bent of mind, and interested in many of those higher questions which are agitating the mind of the age. In 1865 he gave a series of lectures before the Lowell Institute in Boston, which was afterward published (1868) under the title of "Man's Origin and Destiny as seen from the Platform of the Sciences." After being out of print for several years, a new edition of this work was called for, and it was revised and reissued, with six additional chapters, in 1881.

The book abounds in evidence of the author's independence and originality, and of his varied and extensive erudition. It is but just to say, however, that it was not intended as an elaborate or systematic treatise, and it is thus characterized by the author himself: "The author never contemplated anything beyond a general sketch of the present bearings of science upon the vexed question of the origin and early history of man. But the question has many subdivisions. He intended the several lectures to be separate sketches of those subdivisions of the field of discussion—mere introductions to their proper study. His views are stated, therefore, in round terms. Nothing is closely reasoned out. Much is left to the logical instinct, and more to the literary education, of the reader. Reference is everywhere made to sources of information within easy reach of all. Even the style of an essay has been avoided. The book is merely a series of familiar conversations upon the current topics of interest in the scientific world." This spirited book was noticed in Volume XX of "The Popular Science Monthly," and the following estimate was given of it: "We have gone through Mr. Lesley's book with interest and profit—pleased with its brilliant and forcible passages, which are frequent; instructed by its learning and its abounding facts, and stimulated by its incisive observations and its forcible arguments. But the work is strongly stamped with the author's individuality, and its supplementary chapters especially, fresh and breezy as they are, contain various opinions to which we find it impossible to subscribe. But, notwithstanding its faults, the work is original, helpful, and invigorating, and those who are concerned to note the drift of modern inquiry will be sure to find it serviceable."

CORRESPONDENCE.

WHAT KNOWLEDGE IS OF MOST WORTH.

Messrs. Editors:

WHILE this discussion about the great ascendency given the study of the classics in all of our institutions of learning is going on, we beg to offer the following facts: Here we have the great University of Michigan, the pride of the State, with its fourteen hundred students, and schools of literature, science, and the arts, dentistry, law, pharmacy, music, medicine, political and sanitary science, and one can graduate and take the coveted degree of A. B., receive the commendation of his teachers, then study in a post-graduate course and receive the degrees of A. M. and Ph. D., and be an *educated fool* so far as knowing anything of elocution is concerned, or having acquired any knowledge of the structure and composition of his own body or of the laws of health.

To the credit of the university, it may be said that many courses of study are offered and a wide latitude given for choice; but, while four years of study in Latin and two in Greek are required in the preparatory schools and about one and a half year each in Latin and Greek in the university, nothing is required in the fitting schools or university in either elocution or physiology and hygiene, and there is absolutely no provision made in any department for teaching the former, and nothing in the latter is required or offered candidates for the degree of A. B. worthy of the name. It still seems to be considered of vastly more importance to have a smattering of Latin and Greek than to know anything about one's own body and how to care for it, or to speak well our own tongue.

OBSERVER.

ANN ARBOR, MICHIGAN, *May* 28, 1884.

THE QUALIFICATIONS OF LEGISLATORS.

Messrs. Editors:

AFTER reading what Herbert Spencer says of the "Sins of Legislators," I am impressed with the idea that it would be a step in the right direction to make it a necessary qualification for a member of Congress or State Legislature that he shall pass a satisfactory examination before some university board, and get a certificate showing his attainments in the studies of political economy and civil government. This would at least compel candidates for those positions to devote some time to the study of those branches—a thing they now seldom do. I see no reason why they should not be compelled to prepare themselves for their work as much as common-school teachers do now.

J. G. MALCOLM.

TOPEKA, KANSAS, *July* 1, 1884.

"AN EXPERIMENT IN PROHIBITION" FROM ANOTHER POINT OF VIEW.

Messrs. Editors:

THE May number of "The Popular Science Monthly" contained an article entitled "An Experiment in Prohibition," some of the statements in which were so one-sided and inaccurate that they can not be allowed to pass without challenge. Among those statements were assertions that in the State of Vermont the prohibitory law is "an absolute dead letter"; that the returns of the United States revenue officers show that there are in that State *four hundred and forty-six* places where intoxicating liquors are sold; that "in the city of Burlington there are about threescore places where liquor is sold; and in Rutland, St. Albans, and all the larger towns, a proportional number, and in every village in the State, with the exception of a few inconsiderable hamlets, at least one such place"; that "a large proportion of the dram-shops are located upon the principal streets and there is no concealment or attempted concealment of the illegal traffic conducted within them"; and that prosecutions of liquor-sellers, on whom persons arrested for intoxication have disclosed, are "very common," but are confined to "the lowest class of liquor-dealers" and are "invariably for a first offense."

Two of these statements contradict each other. If prosecutions, though only for first offenses and of the lowest class of liquor-dealers, are "very common," it can not be correct to say that the law is an absolute dead letter. Most certainly it is *not* an absolute dead letter.

The statement of the number of places in Vermont where intoxicating liquors are sold was obtained from a newspaper compilation, from the returns of the United States Collector of Internal Revenue for the year ending April, 1883. The same returns show that, of the 446 persons paying the United States tax as dealers in intoxicating liquors, about three hundred were druggists, who must use, and keep, and sell, alcohol and spirits for purposes recognized as legitimate. While some of these undoubtedly sell liquors to a greater or less extent for other than "medicinal, mechanical, and chemical purposes," their shops can not, as a class, be called "dram-shops"—and many

of them guard their sales rigidly. The 446 also include the large manufacturing and wholesale druggists, dealing in alcohol and spirits in large amounts in their trade, yet who are so far from being keepers of "dram-shops," that not only do they not sell spirits to be drunk on the spot, but no one not in the trade, high or low, can obtain alcohol or liquor from them in any quantity, large or small, for individual use, or even for cooking or other family purposes. The 446 include the hotels, some of which have no bars, and are careful how they sell to any but their guests. It is to be remembered also that the man who opened a saloon, sold whisky on the sly, and was visited by the United States revenue officer and compelled to take out a license, was included among the 446, although his alcoholic stock in trade may have been seized next day by the sheriff, and himself sent to the house of correction. These deductions would reduce the number of "dram-shops," properly so called, to a smaller number in proportion to population than in any other civilized community of equal numbers, with the possible exception of the State of Maine.

But if all concerns paying the United States tax were to be called dram-shops, then it is to be noted that the number is much smaller in Vermont in proportion to population than in any State which licenses the sale of liquors. Thus in Massachusetts, which has a "rigid license law," 8,476 persons held United States licenses to sell liquor last year, being one to every 202 of the population. In Connecticut 3,357 persons paid the United States tax, being one to every 187 of the population. In Vermont it appears that 446 paid the United States tax, being one to 744! In other words, more than *three times* as many persons were selling liquor in Massachusetts, and four times as many in Connecticut, in proportion to population, as in Vermont! And, could the amount of liquors sold where the dealer is free to advertise his business and sell all he can be compared with the amount sold where the traffic is under the ban of a prohibitory law, it would doubtless be found that each United States license in Massachusetts, Connecticut, New York, or any other non-prohibitory State, represents a vastly greater sale of liquors than in Vermont.

It is to be noted, further, that the number of persons paying the United States tax in Vermont shows a noticeable decrease in the last ten years, the number returned for the year 1873 being 684. Here appears to be a decrease of some thirty-five per cent in ten years. During the same period the number of United States licenses issued in Maine increased by 78; in Massachusetts, by 208; in Connecticut, by 573; in Rhode Island, by 436. *Something*, evidently, is checking the liquor-traffic in Vermont to a considerable extent, and the universal and strong opposition to the law, on the part of those who consider it to be for their interest to have more rather than less intoxicating drinks consumed, shows clearly that *they* attribute a good part of the restriction to the prohibitory law.

The number of places where liquor is sold in Burlington is overstated. The number in April, 1883, was not threescore, but 49.

It is not the fact that in every village there is at least one such place. Many Vermont villages have no such place, and have not had for twenty years. In more than half of the towns of Vermont, the United States revenue collectors could not find, in the year ending April 12, 1883, any one selling liquor. There are 240 towns in Vermont, and in 127 of these no drug-store, hotel, or dram-shop was found that could be required to pay the United States tax. The statement that there is no concealment or attempted concealment of such illegal traffic as is conducted in the State could hardly be made wider of the truth. As a general thing, the traffic is everywhere concealed from public view. No placard, sign, advertisement, or open bar attracts men to drink. The liquors kept for sale are kept under lock and key, or in dark rooms or cellars; and even then seizures are frequent and fines numerous, and often ruinous to the business, and prosecutions are by no means confined to first offenses, or to liquor-dealers of the lowest class. The law is one which enables the citizens of any town to do what they choose as regards illegal traffic in liquor. If they choose, they can banish it. If they do not care to banish it, they can restrict it, if they will, to almost any extent. In point of fact, in Vermont, as a whole, the law exercises a steady and increasing pressure upon the illegal traffic, and makes it a very risky and disreputable business. To this extent the law is no failure.

Prohibition has been for over thirty years the settled policy of Vermont. The law has been changed by successive Legislatures only to perfect and strengthen it. As the State is admitted to be "a moral and God-fearing community," and its people are not considered specially lacking in intelligence, the fair inference from such extraordinary support and popularity would seem to be that the prohibitory system must have merits for a community like that of Vermont, and that it must have measurably answered its purpose. It is idle to say that this support and popularity are factitious. Bubbles do not last for generations. It might be possible, with effort enough, to manufacture a sudden sentiment for such a system, that might last for a year or two. But it is safe to say that a measure like this, which stands firm year after year, and

decade after decade, against the bitter opposition of an elsewhere powerful interest, among a not particularly visionary people, among a people, in fact, of more than the average independence of judgment and practical hard common sense, must amount to something. This inference I assert to be a correct one. The people of Vermont have sustained the prohibitory law for over thirty years, and will continue to sustain it—not as a lovely theory or a "barren ideality," not as a panacea for all social evils, not as necessarily the best thing for all States and all communities, in their existing conditions; but as the system which is better for *them* than any other they know of; as a system which in spite of the hindrances, defects, and perversities which largely obstruct all moral effort and must be expected, especially, to hinder an effort to curb the gratification of an appetite as general and powerful as that for strong drink, does practically, here in Vermont, restrict the liquor-traffic to a greater extent, and so proves itself a better ally to moral effort to resist intemperance than any other method of restriction they have ever tried, or seen tried elsewhere.

GEORGE GRENVILLE BENEDICT.

EDITOR'S TABLE.

MEETING OF THE AMERICAN SCIENTIFIC ASSOCIATION.

THE thirty-third meeting of the American Association for the Advancement of Science will take place this year at Philadelphia, beginning on Thursday, the 4th of September, under the presidency of Professor J. P. Lesley, Chief of the Geological Survey of Pennsylvania. In order to allow an interchange of courtesies between the American and the British Associations, the latter of which meets the previous week in Montreal, the American meeting is put at a later date than usual. The Council of the British Association has invited the fellows of the American Association to join in the meeting at Montreal on the footing of honorary members; and the American Association and the local committee of Philadelphia have invited the members of the British Association and their relatives who may be with them to take part in the Philadelphia meeting. Invitations have been sent to the leading scientific societies abroad, asking them to send delegations to the Philadelphia meeting, so that it is expected to be largely international in its character, and it is likely that steps will be taken to form an International Scientific Association. An International Electrical Exhibition, under the auspices of the Franklin Institute, will be open at the same time, and the American Institute of Mining Engineers and the Pennsylvania State Agricultural Society will hold sessions at Philadelphia during the same week. On various accounts, therefore, the occasion will be one of unusual interest, and the meeting will probably be fully attended, while the large local committee of Philadelphia may be trusted to make every arrangement possible to conduce to the pleasure and profit of the visitors.

THE BRITISH ASSOCIATION—INTERNATIONAL SCIENCE.

THE British Association for the Advancement of Science holds its fifty-fourth annual meeting this year at Montreal, commencing on the 27th of August under the presidency of Professor Lord Rayleigh, of the University of Cambridge. This is, perhaps, the largest and most powerful scientific society in the world, and its coming from Europe to America is a new departure in its history, of such considerable significance that we may profitably give some attention to it.

The British Association was established in 1831, over half a century ago, and held its first meeting in the city of York. It came into existence in obedience to a growing demand for what may be termed scientific expansion, or

a desire to increase the cultivation and augment the influence of science by bringing larger portions of the community within reach of scientific facilities, and making more familiar the intercourse of men devoted to scientific labors. Numerous societies already existed for the promotion of research, both special and general, but they were local in their operations, while their members met their fellow-workers in different cities but rarely, and multitudes of educated people were not brought within the circle of scientific influence. Yet the number of these societies attested that the work of scientific investigation had taken deep root. Scientific knowledge had become greatly extended, and this led, by the inevitable course of things, to the necessity of more efficient and comprehensive organization for its further increase and diffusion. With the growing sense of the general importance, and the augmenting influence of science in society, there was a strengthening desire to share its work and its advantages, and this naturally led to association upon a new basis, better adapted to the new conditions. The British Association, instead of taking root in one locality, was constituted as a migratory body that should hold its annual sessions, of a week's duration, successively in the different cities of the United Kingdom. It was announced at the first meeting that, while contemplating no interference with the ground occupied by other institutions, its objects shall be "to give a stronger impulse and a more systematic direction to scientific inquiry—to promote the intercourse of those who cultivate science in different parts of the British Empire, with one another and with foreign philosophers—to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress."

These objects of the Association have been well fulfilled in its history. It has been a power in England for the accomplishment of the purposes designated. It has attracted multitudes of capable men to devote themselves to scientific pursuits. It has systematized and promoted observation and research in various fields, and has lent efficient pecuniary assistance to many workers who were without the means for investigation. Its career has been coincident with the highest scientific activity in all civilized countries, and it has lent its powerful co-operation in bringing out many of the grand scientific results that will make the last half-century memorable in scientific history. The British Association has, moreover, been administered from the beginning in a liberal spirit and with enlarged views. While mainly devoted to the extension and the improvement of scientific knowledge, it has never been afraid to express its sympathy with the popular aspects of scientific questions, and it has wisely lent its influence for the encouragement and general promotion of scientific education. Perhaps no higher testimony could be afforded of the excellence of its plan, the value of its labors, and its adaptation to the requirements of the period, than the fact that it has been successfully imitated both in the United States and in different Continental countries.

The coming of this body across the Atlantic to hold one of its annual sessions in Montreal, while quite in accordance with its established policy of enlarging the field of scientific influence, is such a signal stroke of expansion as fitly to make an epoch in its beneficent career. It does not, indeed, overpass the limits of the British Empire, but it migrates to a new continent, and if not to a foreign, at least to a distant and a different people. It seems to us, therefore, that, to reach the highest utility of the occasion, it should be be made subservient to the more systematic organization of international agencies for the promotion of science. While in itself but a transient event, it

is nevertheless a fitting opportunity to initiate something permanent, that shall mark the stage at which we have arrived in the growth of what may be called the international scientific consciousness of the world. Something, indeed, has already been accomplished in this important direction. That large division of the students of Nature, the medical profession, has entered into extensive co-operation on an international scale for the advancement of its interests. The International Medical Congress meets once in three years, each time in a new country, and all who have participated in its proceedings testify to the reality, the extent, and the value of the results attained. There is no reason why similar advantages may not be derived from an international association of scientists devoted to the promotion of the general objects which they have in view. We are glad to observe, as remarked above in referring to the American Association, that steps are being taken to organize such a body on an international basis. It will be but a further and natural development of the policy of the British and American Associations within their respective countries. There is a large field of labor that would especially belong to such a body, for hitherto science has been to no small degree hampered and impeded by the disagreements and conflicts that have arisen out of its limited and national pursuit. An international congress of scientists would be the proper body to promote the adoption of common standards of time, of measurements of all kinds, of biological and geological nomenclatures, of common systems of recording observations and statistics, and the policy of scientific undertakings which require international co-operation, and it would have many things to do which there is no association at present entitled to undertake. The same important advantages of increased personal intercourse among the cultivators of science, to which the existing associations have been tributary in their respective countries, would then be secured on a still wider scale. Nothing is more important than the bringing of scientific men, who are separated by distance and rarely see each other, into personal contact and acquaintance, to gain that intimate understanding of each other which can only come from personal discussion; and this is the more necessary where men are habitually separated by the differences of nationality. There are many reasons why such an organization should be established; the time has come for it, and the present is an especially favorable time for carrying it out. The large attendance of foreign scientists at Montreal is to be followed by the meeting of the American Association in Philadelphia, and many of the foreign *savants* will be present at that meeting. The circumstances are auspicious for taking this new step which, if taken, will undoubtedly be productive of lasting and world-wide advantage in this great field of labor.

But we must not lose sight of the loftier lesson that is so happily illustrated in the coming of this most powerful of scientific organizations to the New World, and which is well calculated to incite to further action in this important direction. What concerns us most is the exemplification it affords of the gathering strength of the great scientific movement in this age. The visit is made in obedience to that development of scientific influence by which it has now become the great leading force of civilization itself. We hear much of the *advancement* of science, as if it were but a movement in one direction; but we must not forget that with progress there has also been a vast widening of the scope of scientific influence and activity. The movement is one of enlargement of ideas, and it is only when we regard the different sciences as fusing into the most vital inter-connections, and reorganiz-

ing human knowledge, that we can begin to understand the import of the epoch upon which we have entered, and appreciate the full meaning of these demonstrations of enlarged operation in the scientific agencies of the period. It was inevitable, from the very nature of things, that science should overleap its past limitations and pass to the stage of international comprehensiveness; but, fully to comprehend this, we must remember that it represents a new epoch of thought, and promises a new education for mankind. The dominant ideas of the past have been confining and restrictive. National feelings are diverse and antagonizing; religions are hostile, and politics local and exclusive; but science is as universal as Nature, its devotees are one in spirit and in purpose, and it is undoubtedly the supreme unifying element of the modern social state. It studies phenomena of every kind, and is equally at home in every place. Its perpetual aim is the dispassionate consideration of facts, and the generalization of wider and more comprehensive truths. Eschewing all narrowness and prejudice, by the very nature of its discipline it tends to break down factitious limitations, it cultivates the spirit of large-mindedness, and is the great teacher of toleration, liberality, and catholicity. By leading to profounder agreements, by awakening broader sympathies, and making possible more harmonious co-operations in the further progress of civilization, the extension of science is full of hopeful encouragement for the best interests of mankind. Under its influence men emerge into the light of new intellectual relations, new opportunities, and new responsibilities. The elevated sentiments by which men of science are more and more animated were thus eloquently expressed by one of the distinguished presidents of the British Association, Sir John Herschel. He said: "Let selfish interests divide the worldly, let jealousies torment the envious; we breathe a purer empyrean. The common pursuit of truth is of itself a brotherhood. In these meetings we have a source of delight which draws us together, and inspires us with a sense of unity. That astronomers should congregate to talk of stars and planets; chemists, of atoms; geologists, of strata, is natural enough; but what is there, equally pervading all, which causes their hearts to burn within them for mutual unbosoming? Surely the answer of each and all—the chemist, the astronomer, the physiologist, the electrician, the biologist, the geologist—all with one accord, and each in the language of his own science, would answer, not only the wonderful works of God, and the delight their disclosure affords, but the privilege he feels to have aided in the disclosure. We are further led to look onward through the vista of time with chastened assurance that Science has still other and nobler work to do than any she has yet attempted."

THE COLLEGE FETICH ONCE MORE.

THE annual season of college commencements and commemorations is past, and it brought with it the customary laudations of classical study in unusual profusion. The stir of the subject by last year's discussions aroused the friends of Latin and Greek, and they seized the favorable opportunities to expatiate with renewed unction upon the unrivaled educational value and importance of these immortal languages. Professor Jebb, the accomplished Greek scholar, formerly of Cambridge, but now of Glasgow University, was brought over to address the Phi Beta Kappa Society of Harvard, in the hope, no doubt, that he would contribute something to undo the mischievous last year's work of Mr. Charles Francis Adams, Jr., in his address before the same body. Professor Jebb, however, gave rise to some disappointment by not taking the *rôle* of a champion of the study of Greek,

but contented himself with drawing an interesting parallel between some of the intellectual activities of the Greeks and those of our own age.

But if Professor Jebb declined to take up the defense of Greek, now so vigorously assailed as well in his own country as in ours, there are other able men who will not blink the glare of the controversy. Among these is Professor Bonamy Price, of Oxford, who, although a teacher of political economy, takes up the cudgels with great vigor for the classical languages. He contributes the leading article to the "Princeton Review" for July, under the title of "What is Education?" The first part of his paper returns an excellent and an unexceptionable answer to his question-title. He denounces the prevailing propensity to "cram" in unsparing terms; he eulogizes *viva voce* in teaching, and thus sums up: "The aim and task of education—independently of the value of the knowledge obtained for moral or or any other purposes—is to cultivate the powers of the understanding, to strengthen and enlarge them, to show how they are to be used in mastering any subject. It seeks to train the young pupil how to use his brain, how to determine and examine for himself the questions put before him, how to handle his mind as a tool, and thus to realize the very purposes for which that mind was given him—in a word, to teach him how to think."

As to the general means of securing this object the suggestions of Professor Price are sound. He says: "Now, what is the educational process to be adopted for accomplishing this great object of teaching a boy how to think? Not, certainly, to set him to read well-written and learned books, to store up their contents in his memory, and then to pour them out at examination. Nor will this great end be reached by learned addresses from tutors, carefully gathered up in notes by the pupils and then followed up by examinations which simply test the attention and the accuracy of the students. This is cram—nothing better. . . . The answer is not difficult; indeed, it may be called obvious; yet how little is it perceived or valued at the present hour even in our most distinguished institutions of education! Its secret lies in skillful questioning by the teacher, in power to make the pupil discover for himself the facts and truths to be gathered up at each place. . . . The work of the teacher is to direct the attention of the student to the facts lying before him, to stimulate his inquiry into the relations which they bear toward each other, what difficulties they present, how they are to be cleared away by thought, what new truths they reveal. To make the pupil find out for himself the answer to be given to each question, as it arises, is the very essence of real education. . . . The pupil's mind is ever kept thinking, putting together, and discovering. The knowledge won is in no small degree his own acquisition, the product of his own intelligence, his own brain. He is incessantly learning how to use the faculties with which his mind is endowed, and with their help, *guided but not told by the teacher*, to gather up the understanding of the subject to be explored."

But now comes the question, What are the studies best adapted to attain this ideal of education? To this Professor Price devotes the second part of his paper; and he here conspicuously illustrates what has been shown a thousand times before, how an elaborate classical culture can so pervert the mind and bias the judgment that the most weighty considerations are absolutely unrecognized. To the broad question what subjects of study are best suited to cultivate, strengthen, and enlarge the powers of the understanding, Professor Price answers: "For value and power it may safely be asserted the study of the Greek and Latin languages stands pre-eminently the first. Greek, above all, has no equal in educating force; it

is the greatest, the most productive tool for developing the minds of the young known to man."

But if, now, we ask how these sovereign advantages are to be secured, or in what does this incomparable virtue of Greek for educational purposes consist, the reply is, that through the mastery of this language the student's mind is brought into close relation with the minds of the greatest men, Plato and Aristotle, Virgil and Æschylus, Thucydides and Demosthenes, Homer and, "above all, Saint Paul"—especially in the Epistle to the Romans.

Professor Price's argument here consists merely of fresh and vivid eulogies of the old Greek masters, and declarations that they are wonderfully fitted to quicken and elevate the minds of students. He maintains that they are excellent instruments of discipline, and this probably but few dispute. His proposition is that Greek and Latin are "pre-eminently the first" among the instrumentalities of mental development; but he neither proves nor attempts to prove it. The idea of "pre-eminence" is relative; it implies superiority to something else; and the argument, to be good for anything, must state the claims and prove the inferiority of that something which is assumed to be inferior. The acquisition of Greek gives a discipline in the study of languages, and that may be the best of all languages for the purpose. The mastery of Greek literature gives a literary training, and it may be the best of all literatures for the purpose. But that is not at all the question. The question is as to the "pre-eminence" of language and literary discipline over any other kind of discipline. The real issue, the issue that has arisen in modern times, is between language and literature on the one hand and science-studies on the other, as instruments of mental development. This essential issue Professor Price does not take up. He does not even recognize the existence of such a thing as a mental discipline gained by the study of science. He refers indeed to science, in the usual classical spirit, as giving useful knowledge to "the lower classes," who have to work for a living. "In the lower classes of life, useful knowledge, knowledge that fits the learner to carry on some special business from which a livelihood is to be obtained, is the object most desired. . . . A little boy may easily be made to understand how a plant grows, how it picks up some substances from the sun and air, or under or from the ground, how it decomposes these substances and extracts from them the parts which they can apply to their own growth." Are we to infer from this slovenly sentence, equally false to the facts of science and the rules of grammar, that an accomplished Oxford classicist holds himself under no obligation to write decent English when coupling the study of science with vulgar laboring people?

Notwithstanding Professor Price ignores it, yet Greek and Latin are on trial before the world under indictment for the fatal deficiency of their educational discipline! They are arraigned as in this respect fundamentally defective because they leave in total neglect some of the most essential powers of the mind. What valid claim has a system of mental cultivation, in this age, which gives no more heed to the important faculty of observation in the youthful mind than if it had no existence; which neglects the study of Nature, and makes no provision for cultivated mental intercourse with the most immediate objects of human experience; which fails to use the great living problems of human interest with which intelligent beings are vitally concerned, as means for the systematic discipline of the reason and the judgment in preparation for the responsible work of life? Here are the opportunities and the urgent needs, and here the possibil-

ity of that varied, methodic, and persistent exercise of the mental faculties which gives them their soundest and most symmetrical discipline. Modern studies have become the rivals of ancient studies, and the discipline of science the rival of classical discipline. The discipline of science is superior to lingual and literary discipline because it involves all the mental processes, because it takes effect upon the realities of experience, because it is a discipline in the pursuit of truth, because it is a preparation for practical life-work, because it uses the most perfected knowledge as its means of culture, and because it brings the mind into intimate and intelligent relation with the system of natural things, which it is the first interest as it is also the highest pleasure of man to understand.

A CORRECTION.

An article contributed to the "North American Review" for August, by Mr. George J. Romanes, an English author, opens with the following passage: "A few months ago I published a work entitled 'Mental Evolution in Animals,' in which I attempted to trace as carefully and thoroughly as I was able the principles which have probably been concerned in the development of mind among the lower animals. This work, I believe, has already been reprinted in America; and seeing that, under the existing state of matters with reference to copyright, an author on this side of the Atlantic is precluded from securing any pecuniary interest in the sale of his work upon the other side, I am free to allude to this book as constituting the basis of the present paper."

We read this statement with some surprise. Had Mr. Romanes said, "The American people deny my ownership of the book that I have made and which they reprint, and I therefore hold myself absolved from recognizing anybody's ownership of the reprint," his position would be intelligible. But, when he says he proposes to make use of its contents as he pleases because he "is precluded from securing any pecuniary interest in the sale of his work" in this country, his statement creates a false impression, and one which we are personally concerned to correct. Mr. Romanes contributed "Animal Intelligence" to the "International Scientific Series," a project which was undertaken expressly in the pecuniary interest of scientific authors; and on all sales of this book the stipulated royalty is placed to his credit, to be drawn by his English publishers. It was intended, as we understand, at first to include the "Mental Evolution in Animals" in the "Series" also; but, although this was not done, it is to be paid for under arrangement by the American publishers at the same rate. When the profits are earned by the sale of the volume, Mr. Romanes will be entitled to them by contract, and he thus stands upon the same practical footing as an American author.

LITERARY NOTICES.

Outlines of Psychology, with Special Reference to the Theory of Education. By James Sully, author of "Illusions," etc. New York: D. Appleton & Co. Pp. 711. Price, $3.

Mr. Sully has brought to the preparation of this comprehensive work unusual accomplishments for the task. He is well known as an indefatigable student of mental science, and his numerous contributions to the leading English periodicals, on advanced pyschological questions, give him a high rank both as an original inquirer and an attractive and successful writer upon these subjects. He is the author of several systematic works, one of which, on "Illusions," prepared for the "International Scientific Series," has been republished in this country. Mr. Sully is thoroughly familiar with the results and methods of the modern English school of psychological thought, and he has also pursued his studies in Germany under the ablest masters, so that he is well equipped for dealing with the subject in the light of the most advanced views. It

may be added that he is no partisan and no extremist, but writes with care, moderation, and judicial fairness, taking impartial advantage of the best that has been gained by the various schools of investigation. Recognizing the importance of introspection as an instrument of psychological observation and analysis, he supplements it by the physiological study of the nervous conditions and concomitants of mind. His general point of view is that of evolution, and his capacity of handling his subject by this method may be inferred from the fact that he was chosen in conjunction with Professor Huxley to write the elaborate article on "Evolution" for the present edition of the "Encyclopædia Britannica." It may be added that his book is one of great clearness, and will prove of unusual interest to the general reader, while as a text-book of mental science it undoubtedly has merits superior to any other treatise now before the public.

We pointed out editorially, not long ago, in an article entitled "The Progress of Mental Science," the important results that have flowed from the widening of the method in mental studies by which metaphysical speculation has been supplemented by the knowledge of mind, as physiologically conditioned, and we showed that the benefits of this change are conspicuous in the practical results obtained. The time has come when the validity of the science of mind is to be largely tested by such practical applications, and we have noted with gratification that Mr. Sully accepts this view, and has constructed his treatise with reference to it. While the work is, of course, mainly a strict and systematic treatise on psychological science, presenting its elements in their due proportions, yet the author throughout has developed its practical bearings upon the art of education. In regard to this feature of his work, the author makes the following remarks in his introduction:

> Finally, I have sought to give a practical turn to the exposition, by bringing out the bearings of the subject on the conduct and cultivation of the mind. With this object I have ventured to encroach here and there on the territory of logic, æsthetics, and ethics—that is to say, the practical sciences which aim at the regulation of the mental processes. Further, I have added special sections in a separate type, dealing with the bearing of the science of education.
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> I would fain think that these practical applications will not be without interest to all classes of readers; for everybody is at least called on to educate his own mind, and most people have something to do with educating the minds of others as well. With respect more especially to professional teachers, I trust that these portions of my volume may serve to establish the proposition that mental science is capable of supplying those truths which are needed for an intelligent and reflective carrying out of educational work. I may, perhaps, assume that modern pedagogics has adopted the idea that education is concerned not simply with instruction or communicating knowledge, but with the training of faculty. And it seems a necessary corollary from this enlarged view of education that it should directly connect itself with the science which examines into the faculties, determines the manner and the conditions of their working, and lastly traces the order of their development.

This characteristic of Mr. Sully's work we hold to be of especial importance; for, although no great amount of space is given to the subject of education, yet the whole course of the exposition is so tributary to it that what is stated has a high and peculiar value. The lessons for the teacher are derived immediately from the latest and broadest views on the subject of mind. The time has gone by when the old modes of studying this subject are satisfactory. That a teacher has read up a lot of metaphysical treatises and become familiar with their subtile dialectics and old terminology is no evidence whatever of competency to guide the processes of mental development. Rather is it a disqualification, for a mind saturated with the antiquated mental philosophy is certain to be prejudiced against the new and better methods. It is indisputable that there has been a radical change and a vast improvement in the study of mind, within recent years, and the teacher who has not benefited by that improvement is fundamentally deficient in the preparation for his work. The author of this treatise has therefore done a most important service in dealing with the subject of education, in connection with his broad presentation of the present state of knowledge upon the subject of psychological science.

THE TRUE THEORY OF THE SUN. By THOMAS BASSNETT. New York: G. P. Putnam's Sons. Pp. 264, with Plate. Price, $3.

MR. BASSNETT is the author of the "Outlines of a Mechanical Theory of Storms"

which he published some thirty years ago, and the substance of which he presented before the American Association, to have its principle found inadequate by the committee to whom the subject was referred. For this treatment and for other evidences of lack of appreciation which he has received at the hands of men of science, he is still grieved. He continues to press his theory, and now expands it and extends it to solar storms and their influence. It presupposes vortexes in the ethereal medium in connection with the motions of the earth and the planets, and the exertion by the moon of disturbing influences upon the terrestrial vortexes, producing electrical action and storms. The author believes that he has ascertained the law of the disturbances, and can accurately predict the occurrence of storms in any part of the earth. A common origin in similar phenomena is hypothecated for solar spots and the corona and for atmospheric changes and cyclones. Those may test the theory who are able to master it and wish to try the experiment; four tables are given for computing the maximum and minimum epochs of solar activity and "the passage in time and place of the chief disturbances from the equator to the poles in both hemispheres."

THE CONSOLATIONS OF SCIENCE; or, Contributions from Science to the Hope of Immortality, and Kindred Themes. By JACOB STRAUB. With an Introduction by HIRAM W. THOMAS, D. D. Chicago: The Colegrove Book Company. Pp. 435. Price, $2.

THIS work comes to us very highly commended for its admirable spirit, its masterly criticism, and its exalting views, by such men of thought as President Porter, Rev. Robert Collyer, and Professor Swing, and we have no doubt that many people will enjoy it, and find themselves helped and encouraged in their religious aspirations by the views it presents. The author has mastered the tendencies of modern science, and finds that the profoundest lesson to be drawn from them is that the most real, lasting, and powerful things are invisible, and on the basis of all that science has revealed he claims to gain strong confirmation of the belief in a future state of existence, and the immortality of conscious being. But while it is no doubt possible to appeal in this way to science for consoling encouragements in regard to the future and everlasting life, it can only be by great freedom and boldness of speculation that reassuring responses can be returned. It is not in the power of science to prove the truth of immortality. Science can only deal with the phenomena of time and experience, and whatever transcends these must be left to the sphere of faith.

GOVERNMENT REVENUE, ESPECIALLY THE AMERICAN SYSTEM: AN ARGUMENT FOR INDUSTRIAL FREEDOM AGAINST THE FALLACIES OF FREE TRADE. By ELLIS H. ROBERTS. Boston: Houghton, Mifflin & Co. Pp. 389. Price, $1.50.

THIS volume has a claim to the attention of readers, first, because of the information which it contains on the subject of government revenue; next, because it is a hot polemic in behalf of protection, and against free trade, full of ingenious arguments; and, lastly, because its contents have been delivered as lectures before the students of Cornell University and of Hamilton College.

The book abounds with facts upon financial and economical subjects, indicating the author's wide and critical reading. But facts with him are valuable only as tributary to theories. Accordingly, he argues broadly on the basis of his multitudinous data against the freedom of commerce, and in favor of the protective system, and the political regulation of the industries of the country.

The delivery of his views before college classes was by no means a bad idea. Something is, indeed, to be said in favor of limiting collegiate study to subjects which are settled in their principles; and political economy has long been recognized as fitted for college study because it involved established truths of great public importance. But among these have been the principles of free trade, so that these institutions have become centers of propagandism of this doctrine. That the advocates of protection should not be satisfied with this, is only natural; but, instead of trying to suppress the objectionable teachings, they have more wisely attempted, as in this case, to correct the evil by presenting the claims of the op-

posite system. The difficulty is, how far this policy can be carried. Will the authorities of Cornell University permit Mr. Ignatius Donnelly, author of "Ragnarok," to go before its classes and present the other side of the accredited geology? Mr. Donnelly's case is of the same kind, and quite as strong as Mr. Roberts's.

Mr. Roberts's theme is, "The Subject of Revenue, especially the getting of Money for the Public Treasury." It "relates to filling the Treasury, and not to emptying it; we are to find out about the income of states"; and this "will bring us immediately upon the relations of government to the people." We infer, from looking over his book, what seems to be confirmed by all history, that it is the great, primary, universal business of all government to get money out of the people; and the question is, as to the easiest and most effectual way of accomplishing this object. Mr. Roberts maintains, and we think he proves, that the most successful way of extracting money from the people is not openly to demand it, as something honestly due to government, but by the indirect process of levying exactions upon commerce. Mr. Roberts shows that this is the ancient, the favorite, and most extensively employed method; and, if the object of government be solely to raise money, without regard to any other consideration, beyond doubt the taxation of commerce is the best method. But the taxation of commerce is a burden upon it, restricting its freedom, and disturbing the price of the commodities taxed. This consequence of the repression of foreign commerce has been utilized for the regulation of the home industries of nations by the so-called protective system, which is a natural result of the revenue system expounded by Mr. Roberts, and they are accordingly both defended together.

There is one feature of our author's argument which at this time is something of a curiosity. He calls this old system of restriction and protection, which has been a favorite with kings, tyrants, and oligarchies from the beginning for plundering the people, "the American System." Many will remember the brilliant passage in Daniel Webster's celebrated free-trade speech of 1824 (left out of Everett's edition of Webster's works), in which he exposed with merciless invective the absurdity of Henry Clay in calling the ancient policy of commercial restriction "the American System." Yet sixty years later Mr. Roberts finds this designation quite as available as ever. But, after proclaiming "the American System" on his title-page, Mr. Roberts proceeds in the very first paragraph of his first chapter to show that the policy is as old as the Pharaohs. The King of Egypt "took his tribute also from all merchants who entered his land." Among the various despotic ways of extorting money from the Egyptian people, "commerce contributed its full share by traffic in the name of the ruler, by charges on traders, and the first example of an export duty is traced to that ancient land." Not only the people, but both kings and priests, "were forbidden to use any article not produced in the country. The development of all classes of production was thus persistently fostered." The policy, it would seem, might thus be properly named the Egypto-American policy, but that our author shows that it has been substantially adopted by all governments from the time of the earliest Pharaoh to President Arthur.

Our author's reasoning upon this subject reminds us of the logic prevalent among the American people a quarter of a century ago in regard to the peculiar system of protecting the negro. It was maintained that this is best done by his enslavement, inasmuch as the enslavement of man, in one form or another, has been practiced in all communities and at all times. The restrictions upon trade and the regulation of industry by levies upon commerce are urged as having precisely this sanction, for, as Mr. Roberts says:

"No axiom of morals, no doctrine of any creed, hardly any fact in science outside of pure mathematics, has ever been so uniformly sustained by the teachings and practice, certainly not by such a consent of legislation, of mankind in all ages," as restraints upon the liberty of trade and the freedom of industry.

But Mr. Roberts evidently does not relish the idea of being ranked as an enemy of all freedom in the business affairs of the people in this country and in this age. He proclaims that men should be free to work or that they should be at liberty to produce

what they like and as they like, and only be manacled when they come to dispose of their productions. He has a great deal to say about "liberty of production" and "industrial freedom." He must therefore think that men, if "let alone," and left free to exercise the largest option in the choice and pursuit of vocations, will *create* more property than if hampered and meddled with by government.

But why the same principle would not apply to the exchange of property, and why wealth would not be further augmented by the liberty of citizens to sell and buy the products of labor when and where they will, without let or hindrance, he does not explain. His concession of "the liberty of production" is, however, illusory. Commerce and industry are so bound up together that you can not fetter the former without restricting the latter. Indeed, one of the avowed purposes of repressing commerce is the coercion of production. As trade is not free if hindered or paralyzed by legislative action, so production is not free if forced by government into artificial channels, and regulated by politicians rather than left to the open competitions of private enterprise.

SIX CENTURIES OF WORK AND WAGES. The History of English Labor. By JAMES E. THOROLD ROGERS, M. P. New York: G. P. Putnam's Sons. Pp. 591. Price, $3.

IN the midst of the deluge of books on social questions—labor, wages, land, co-operation and what not—most of them mere wild and worthless speculations, we turn with a sense of refreshing relief to this solid contribution to the subject from the point of view of simple historic facts. Professor Rogers is known as a political economist of wide acquirements and independent opinions, but he is so far imbued with the scientific method as to recognize that our first need is to get command of the facts of experience in a form available for the derivation of safe conclusions. Some eighteen years ago he published the first two volumes of a comprehensive "History of Agriculture and Prices," and the present volume is but a continuation of his line of studies in this general direction. The work is nothing less than a contribution to the social history of England, treated with reference to the conditions of the laboring-classes at various periods, their opportunities of labor, their rates of wages, their social privations and comforts, and all with reference to the influence of government and legislation, and the constitution of English society.

The theme is a noble one, and it is handled with great instructiveness, and with a sustained interest from the beginning to the end of the volume. It should have a place in every library, and is one of the books that must be carefully consulted by all students of social economics. The following passage, from the review of the London "Academy," exemplifies the character of the questions dealt with in Professor Rogers's work:

> It is an honest and scholarly attempt to reconstruct the social state of England in the thirteenth century, and, from that as a starting-point, to trace the changes in the position of the laboring-classes from the time when many of the peasants were slaves, and most of them in a condition not far removed from serfdom, to the crisis when, by reason of plague and famine, the laborers, "as by a stroke," became suddenly the masters of the situation. The great pestilence made labor scarce, while at the same time the bonds were loosened which tied the laborer to the land. Wages were high, and food remained cheap; and, although continual attempts were made to reduce wages by act of Parliament, it may be fairly said that "the golden age of the English laborer" continued until the change in agriculture caused by the commercial disturbance which followed the discovery of America. The flow of gold and silver to Europe led to a rise in the prices offered in the Continental markets for English hides and wool; and this turned the landlords' attention from the old arable farming in common field to the rotation of grass and grain in the mixed husbandry that enabled them to meet the demand.

KEY TO NORTH AMERICAN BIRDS. Second edition, revised to date, and entirely rewritten. By ELLIOTT E. COUES, M. D. Boston: Estes & Lauriat, Pp. 863. Price, $10.50.

THIS splendid and profusely illustrated book contains, to quote from its full title, a concise account of every species of living and fossil bird at present known from the continent north of the Mexican and United States boundary, inclusive of Greenland. The account is preceded by a general ornithology, or outline of the structure and classification of birds, and a field ornithology, or manual of collecting, preparing, and preserving birds. The whole is preceded by an "Historical Preface," in which the progress

of American ornithology is outlined and divided off into periods, from its beginning in the seventeenth century to the present time. The first edition of Professor Coues's "Key" appeared in 1872, in an issue which was not stereotyped, and has been long out of print. It was composed upon the same general plan, and with the design of reaching the same ends, as the present edition, but had an artificial key to assist in the reference of specimens directly to their genera, which has not been found useful enough to justify its retention. It answered its purpose well, of giving such descriptions of species as would enable the student to identify and label them with no other aid than itself afforded. It had a useful career till the issue was exhausted and no more copies could be had. During the twenty years that elapsed before the present edition was ready for the press, American ornithology had a great development. The number of distinguished species increased to nearly nine hundred; numerous treatises were published on the subject; a distinctly American school grew up, introducing important changes in nomenclature and classification; and an American Ornithologists' Union was founded, with members in all quarters of the globe. In preparing this edition, the classification and nomenclature have been modified to suit the growth of the science; the author's "Field Ornithology," published separately in 1874, has been incorporated in the volume; the outline of "Structure and Classification" has been greatly amplified; and the descriptions of genera, species, and sub-species have been made much more elaborate, without loss, the author hopes, of that sharpness of definition which was the aim of the first edition and still having prominently in view the main purpose of the identification of specimens. The trinomial nomenclature, for the designation of sub-species and varieties—which "lends itself so readily" to the nicest discriminations of geographical races and the finest shades of variation—has been employed with much advantage, but not without a caution by the author against a too free use of it. The references to authorities, which were numerous in the first edition, have been omitted, and their place filled with additional notes about the habits and nesting of the species. The present edition contains about four times as much matter as the former one, and more than double the number of illustrations. We are sorry to observe that the author has not, in his preliminary chapters, preserved the dignity of style that is becoming in scientific works, or in any serious work, but has allowed himself to indulge too often in sensational expressions and jokes that are not always new or refined, to the unnecessary expansion of the text, without adding to its lucidity or its interest. The fault is not so obvious in the descriptive part of the book.

MENTAL EVOLUTION IN ANIMALS. By GEORGE JOHN ROMANES, F. R. S., author of "Animal Intelligence." With a Posthumous Essay on "Instinct," by CHARLES DARWIN. New York: D. Appleton & Co. Pp. 411. Price, $2.

IN these systematic studies into the science of mind to which Mr. Romanes has recently appeared as an original contributor, the course of research breaks into three divisions. In the first, "Animal Intelligence," which appeared in the "International Scientific Series," the author devoted himself to the general data of his subject, or to the statement of the basal facts of comparative psychology. The book is chiefly descriptive of mental phenomena as observed in the lower animals, and aims at greater strictness than has hitherto been attained in determining what is trustworthy and what is doubtful among the alleged statements of fact in regard to mental manifestations among the lower creatures. As the volume was, however, a preparation for the study of psychological theories, its facts were chosen with reference to their bearing upon psychological principles to be subsequently investigated; the law of evolution was accepted as the guiding principle of the investigation, but the elaboration of the theory was postponed to a separate work. It was Mr. Romanes's intention to devote his second volume to the general discussion of evolutionary doctrine as displayed in mental phenomena of all orders; but, as he proceeded with the inquiry, materials accumulated, and the subject expanded to such proportions that it became necessary to divide the second part into two treatises—the one devoted to the evolution of mind in the lower animals, and

the other to the evolution of mind in man. The volume now before us, the second published, is an exposition of comparative psychology on the basis of his first volume, and designed to exhibit mental evolution in the lower grades of the animal kingdom. The psychology of man is therefore expressly excluded from the volume before us, and the author offers, as one reason for this exclusion, that human psychology raises a class of questions with which he has no concern in dealing with comparative psychology. Prominent among these he assumes is the fundamental question whether, indeed, the principle of evolution is to be applied to the psychology of man. Although unqualifiedly assumed in his first volume and in the present as fundamentally true, and the sole key of interpretation in the lower sphere of mind, yet the author hesitates in its application to human psychology because Mr. Wallace differs with Mr. Darwin upon this subject. The issue between these great naturalists is, however, to be met and fully considered in the final volume.

Mr. Romanes explains in his introduction that, in treating of "Mental Evolution in Animals," he dismisses a class of inquiries hitherto involved in psychology, but which pertain rather to the philosophy than to the science of the subject. He deals with the science of psychology as distinguished from any theory of knowledge, limiting himself to the study of mind as an object, and of mental modifications simply as phenomena.

We can only briefly indicate the course of inquiry in the volume before us. Beginning with a search in the first chapter for "The Criterion of Mind," he then passes on in successive chapters to "The Structure and Functions of Nerve-Tissue," "The Physical Basis of Mind," "The Root Principles of Mind," "Consciousness," "Sensation," "Pleasures and Pains," "Perception," "Imagination," "Instinct," and this latter subject, which is the most prominent in the discussion, runs on from chapter eleventh to chapter eighteenth. "Reason" and "Animal Emotions" then come in for some consideration, and the volume closes with an appendix of thirty pages, consisting of a posthumous essay on "Instinct," by Mr. Charles Darwin, which was written for his book on "Natural Selection," but not included in it. Mr. Darwin left his psychological manuscripts to Mr. Romanes, to be printed or not as he thought fit, and he has included the essay on "Instinct" in his present disquisition on "Mental Evolution in Animals." It has been objected that Mr. Darwin was no psychologist; that he wrote on the subject long ago, and did not himself see fit to print what he had written; and that, on the whole, it would have been better for Mr. Darwin's reputation, and just as well for the world, if this old essay had not now been issued. But we think that Mr. Romanes was right in printing it. It can not seriously injure Mr. Darwin's reputation; and, if it does not help other people much, it will undoubtedly have interest as a record of the state of Mr. Darwin's mind upon that subject. If not a contribution to "Mental Evolution in Animals," it may possibly help to interpret the mental evolution of man.

THE FRANCO-AMERICAN COOKERY-BOOK; or, How to live well and wisely Every Day in the Year: containing over Two Thousand Recipes. By FÉLIX J. DÉLIÉE, Caterer of the New York Club, ex-Chef of the Union and Manhattan Clubs. New York: G. P. Putnam's Sons. Pp. 620. Price, $4.

THIS considerable volume claims to fill a void in our culinary literature. It presents three hundred and sixty-five different dinner-bills of fare, one for each day in the year, made up with reference to the resources of the changing seasons, and, following each, concise instructions are given how to prepare the various dishes designated. Such a work can not fail to be of service, not only to private families, but to clubs, restaurants, and hotels, and it could hardly have a better passport to general use in this country than the name of the experienced *chef* which appears upon its title-page. Each bill of fare differs almost entirely from the others, while at the same time the selection is made with strict regard to the products of the season and the supplies afforded by markets in American cities. Each is calculated for eight persons, though the cook or housekeeper may increase or reduce it at will by observing the proportions with care.

It is claimed that every dish described

may be prepared by a cook of ordinary intelligence and even limited experience—probably a pretty large claim. Particular attention seems to have been given to the preparation of soups, fish, and *entrées*, the reason assigned being that these branches of culinary art are too generally neglected in English cookery-books. The staple of the volume is, of course, its recipes, of which there are over two thousand, the several recipes used for the preparation of each dinner following immediately the bill of fare. In the index at the end of the volume every recipe is named, together with the number of the bill of fare to which it belongs.

The use of such a work where cookery is carried on in a somewhat ambitious and systematic way, and with some reference to its artistic refinements, is obvious enough, but it might undoubtedly prove helpful where the culinary processes are comparatively plain and simple. Perhaps it would be invidious to rank any one defect in ordinary cookery as worse than another, where they are all sufficiently conspicuous; but one of its most common defects is its distressing monotony, a few dishes being repeated over and over, with hardly an attempt at variation, while "canned products" enable the housekeeper to be exempt from the resources of the seasons, and to maintain the dreary monotony of dishes all the year round. Much of this is due to indifference and carelessness on the part of those who have kitchen operations in charge, and there are often dolorous complaints of the narrowness and poverty of the *cuisine*, when the real difficulty is that the manager will not give sufficient thought to it. Such a cyclopædia of culinary variations as the present ought certainly to give relief in this respect, and, if it can not be fully carried out, it offers abundant suggestions from which a varied and attractive dietary can be realized.

A Contribution to the Geology of the Lead and Zinc Mining District of Cherokee County, Kansas. By Erasmus Haworth. Oskaloosa, Iowa. Pp. 47.

A careful special study of a particular ore-bearing district of limited extent, prepared as a thesis in connection with an application for the degree of Master of Science from the Kansas State University.

Report on the Cotton Production of the State of Georgia. By R. H. Loughridge, Ph. D., of Berkeley, California. Pp. 184, with Maps.

With the special report Dr. Loughridge gives a description of the general agricultural features of the State. He has been assisted in both parts of the work by A. R. McCutchen, for Northwest Georgia. Georgia ranks first among the States in the acreage (2,617,138) devoted to the cotton-crop, and second—standing next after Mississippi—in the number of bales produced. Cotton is the chief crop of the State, and occupies thirty-four per cent of the land under cultivation, and 44·4 acres per square mile of all the land of the State. The average yield is one third of a bale per acre. The cost of production, exclusive of commissions, freights, etc., is about eight cents a pound. The subject of an "intensive" system of culture has lately attracted much notice, and some enormous yields have been realized. The report is full of information bearing upon every agricultural aspect of the State and of its several counties.

Whirlwinds, Cyclones, and Tornadoes. By William Morris Davis. Boston: Lee & Shepard. Pp. 90. Price, 50 cents.

This is a condensed meteorological study proposing a theory of storms, which formed the basis of a course of lectures by the author at the Lowell Institute in Boston in 1883. It was first published in several numbers of "Science," and is now reprinted with slight alterations in more convenient form. It will be a welcome addition to our slender resources in this field of scientific literature.

Massachusetts State Agricultural Experiment Station. Bulletins Nos. 7, 8, and 9. Pp. 12 each.

Bulletin No. 7, March, 1884, contains "Observations in regard to Insects injurious to the Apple," and "Experiments with Special Fertilizers in Fruit-Culture"; No. 8, April, "Fodder and Fodder Analyses, and "Valuation" and "Analyses" of Fertilizers; No. 9, May, "Notes upon Insects injurious to Farm and Garden Crops," and "Analyses of Fodder and Fertilizers."

SYNOPSIS OF THE FISHES OF NORTH AMERICA. By DAVID S. JORDAN and CHARLES H. GILBERT. Washington: Government Printing-Office. Pp. 1,018.

THE "Synopsis" is published as Bulletin No. 16 of the United States National Museum. In it the authors have endeavored to give concise descriptions of all the species of fishes known to inhabit the waters of North America, north of the boundary between the United States and Mexico. The classification adopted is essentially based on the views of Professors Gill and Cope. The rules of nomenclature generally recognized by naturalists, and recently formulated by Mr. W. H. Dall, have been followed, almost without deviation. Under the head of each species enough synonomy has been given to connect this work with other descriptive works, and no more; and the principal references are to the original descriptions of such species, to Dr. Günther's "British Museum Catalogue," and to other works in which special information is given, or some variant specific name is employed.

HOME SCIENCE, Vol. I, No. 1, May, 1884. New York: Selden R. Hopkins. Pp. 112. Price, $2.50 a year.

A MONTHLY magazine, the general scope of which is indicated by the title. The present number contains a variety of literary, popular scientific, and hygienic articles by popular authors, a "Health and Habit" department by Dio Lewis, and departments of a "domestic" character. The magazine is well printed, on good paper, and looks well.

REPORT TO THE SECRETARY OF THE NAVY ON RECENT IMPROVEMENTS IN ASTRONOMICAL INSTRUMENTS. By SIMON NEWCOMB, Washington: Government Printing-Office. Pp. 27.

PROFESSOR NEWCOMB visited the principal observatories in Europe in 1883, for the purpose of taking note of the improvements in astronomical instruments which had been adopted in them, and this report embodies the results of his observations. Among the objects he describes are the great Vienna telescope and its mountings; the great domes at Paris and Vienna; the great Russian telescope at Pultowa, with the apparatus for mounting it, now making at Hamburg; reflecting telescopes in France, the equatorial *coudé* (a contrivance by the aid of which the eye-piece may always point to the north), the Strasburg meridian circle, etc. The observations are supplemented by the author's own practical conclusions.

AMERICAN METEOROLOGICAL JOURNAL, Vol. I, No. 1, May, 1884. Professor M. W. HARRINGTON, Editor. Detroit, Michigan: W. H. Burr & Co. Pp. 39. Price, $3 a year.

THIS journal is designed to be a monthly review of meteorology and allied branches of study. It takes up the subject earnestly and in a manner showing that the editor has a proper comprehension of what such a publication should be.

PUBLICATIONS RECEIVED.

United States Bureau of Statistics. Quarterly Report on Imports, Exports, Immigration, and Navigation, January to March, 1881. Washington: Government Printing-Office. Pp. 88.

Question-Book of Stimulants and Narcotics. By C. W. Bardeen. Syracuse, N. Y.: C. W. Bardeen. Pp. 40. 10 cents.

Knickerbocker Ready Reference Guide to 1,000 Points around New York. New York: National Railway Publication Company. Pp. 248. 25 cents.

On Induction in Telephone Lines, and Methods for its Prevention. By Edward Blake. Sheffield Scientific School, New Haven, Conn. Pp. 8.

South Side Views. By Rev. W. J. Scott. Atlanta, Ga.: James P. Harrison & Co. Pp. 50. 50 cents.

Scientific and Poetical Works of the Last of the Hereditary Bards and Skalds. Chicago: J. M. W. Jones Company. Pp. 95.

A Judicial Revolution. By Redmond Gibbons. New York. Pp. 8.

"Paleontological Bulletin." No. 38. By Professor E. D. Cope. Pp. 88.

Civil-Service Reform. By Eliel F. Hall. Temple Court, New York City. Pp. 12.

The Tertiary Marsupialia. By E. D. Cope. Philadelphia. Pp. 12.

Limits of Knowledge and Grounds of Belief. Anon. Pp. 20.

Institutional Beginnings in a Western State. By Jesse Macy. Baltimore: N. Murray. Pp. 38.

The Philosophy of Social Economy. By Stewart Bruce Terry. Glendale, Mo. Pp. 20.

Abnormal Human Skulls from Stone Graves in Tennessee. By F. W. Putnam. Cambridge, Mass. Pp. 3.

Catalogue of the Albany Medical College, Albany, N. Y. Pp. 20.

A New Stand (Chick's) for Skulls. By F. W. Putnam. Cambridge, Mass.

The Creodonta. By E. D. Cope. Pp. 30.

The Mastodons of North America. By E. D. Cope. Pp. 3.

Reasons for believing in the Contagiousness of Phthisis. By W. H. Webb, M. D. Philadelphia. Pp. 16.

American School of Classical Studies at Athens. Report of Director, 1882-'83. Washington: Government Printing-Office. Pp. 13.

Circular of Bureau of Education on Shorthand. Washington: Government Printing-Office. Pp. 139, with Plates.

Illiteracy in the United States, by Charles Warren, M. D.; and National Aid to Education, by J. L. M. Curry, LL. D. U. S. Bureau of Education. Pp. 99.

Mississippi State Board of Health. Biennial Report, 1882–'83. Jackson, Miss. Pp. 204.

Hillocks of Angular Gravel and Disturbed Stratification. By T. C. Chamberlain. Pp. 14.

Report on the Cotton Production of the State of Florida. By Eugene Allen Smith, Ph. D. Tuscaloosa, Ala. Pp. 77, with Maps.

Report on the Cotton Production of the State of Alabama. By Eugene Allen Smith, Ph. D. Tuscaloosa. Pp. 163, with Maps.

Diccionario Tecnológico (Technological Dictionary), Spanish and English. No. 7. New York: Nestor Ponce de Leon. Pp. 48. 50 cents.

Temperature of the Atmosphere and Earth's Surface. By Professor William Ferrel. Washington: Government Printing-Office. Pp. 69.

Notes on the Opium Habit. By Asa P. Meylert, M. D. New York: G. P. Putnam's Sons. Pp. 87. 40 cents.

The University: What it should do and be. By S. M. Clark. University of Iowa, Iowa City. Pp. 16.

The Science of Justice, etc. By Lysander Spooner. Boston: Cupples, Upham & Co. Pp. 22.

The Revelations of Fibrin. By Rollin R. Gregg, M. D. Buffalo, N. Y. Pp. 7.

Theories of Color-Perception. By Swan M. Burnett, M. D. Washington, D. C. Pp. 25.

Première Application à Paris de l'Assainissement suivant le Système Waring (First Application in Paris of Waring's System of Sanitation). By Ernest Pontzen. Paris. Pp. 22, with Plates.

Geological and Natural History Survey of Minnesota, 1882. By N. H. Winchell. Minneapolis. Pp. 220, with Maps.

University of Minnesota. Calendar for 1883–'84. Pp. 128.

Contributions to the Flora of Cincinnati. By Joseph F. James. Pp. 14.

The Minnesota Valley in the Ice Age. Pp. 16; Changes in the Currents of the Ice of the Last Glacial Epoch in Eastern Minnesota. Pp. 4. By Warren Upham. Salem Press, Salem, Mass.

Neglect of Bodily Development of American Youth. By A. Reinhard. Syracuse, N. Y.: C. W. Bardeen. Pp. 16.

The Bearing of certain Determinations on the Correlation of Eastern and Western Terminal Moraines. By Professor T. C. Chamberlain. Pp. 5.

Property in Land. A Passage-at-Arms between the Duke of Argyll and Henry George. New York: Funk & Wagnalls. Pp. 77. 15 cents.

To Mexico by Palace-Car. By James W. Steele. Chicago: Jansen, McClurg & Co. Pp. 96. 25 cents.

White Elephant Chimes. Selected by P. T. Barnum. Buffalo, N. Y.: Courier Office. Pp. 51.

"Catholic"; An Essential and Exclusive Attribute of the True Church. By Right Rev. Monsignor Capel, D. D. New York: Wilcox & O'Donnel Company, and D. & J. Sadlier. Pp. 140. 50 cents.

Modern Reproductive Graphic Processes. By James S. Pettit. New York: D. Van Nostrand. Pp. 127. 50 cents.

Recent Progress in Dynamo-Electric Machines. By Professor Sylvanus P. Thompson. New York: D. Van Nostrand. Pp. 118. 50 cents.

Stadia Surveying. By Arthur Winslow. New York: D. Van Nostrand. Pp. 148. 50 cents.

Lessons in Chemistry. By William H. Greene, M. D. Philadelphia: J. B. Lippincott & Co. Pp. 357. $1.25.

South Carolina: Resources and Population; Institutions and Industries. Published by the State Board of Agriculture. Columbia. Pp. 726.

Systematic Mineral Record. By Edward M. Shepard. New York and Chicago: A. S. Barnes & Co. Pp. 26.

The Principles of Ventilation and Heating. By John S. Billings, LL. D. New York: "The Sanitary Engineer." Pp. 216. $3.

Commentaries on Law. By Francis Wharton, LL. D. Philadelphia: Kay & Brother. Pp. 856.

The Book of Plant Descriptions and Record of Plant Analysis. By George C. Groff, M. D. Lewisburg, Pa.: Science and Health Publishing Company. Pp. 100. 30 cents.

Forestry in Norway. By John Croumble Brown, LL. D. Edinburgh: Oliver & Boyd; Montreal: Dawson Brothers. Pp. 227.

POPULAR MISCELLANY.

Instruction of the Deaf.—Mr. Alexander Graham Bell addressed the Philosophical Society of Washington at one of its recent meetings on the subject of "Fallacies concerning the Deaf, and the Influence of those Fallacies in preventing the Amelioration of their Condition." He condemned the common phrases "deaf and dumb" and "deaf-mutes," as expressing what is not true; showing that those whom we term "deaf-mutes" have no other natural defect than that of hearing, and that they are dumb not on account of lack of hearing, but of lack of instruction. No one teaches them to speak. The gesture-language which such a child may use is developed by him at home, not because it is the only form of language natural to one in his condition, but because his parents and friends neglect to use the English language in his presence in a clearly visible form. The sign-language of our institutions is objected to as an artificial and conventional language, so far from being natural that it is not understood by deaf children on their entrance to an institution, and hearing persons can not be qualified to teach it till after many years. Practice in it hinders the acquisition of the English language; makes the deaf associate together in adult life, and avoid the society of hearing people; and thus causes the intermarriage of the deaf and the propagation of their physical defect. Dr. Bell holds that written English can be taught to deaf children so as to become their vernacular, and that, when they have been made familiar with it in either its written or spoken form, they can be taught to understand the utter-

ances of their friends by watching the mouth. The requisites to the art of speech-reading are, an eye trained to distinguish quickly those movements of the vocal organs that are visible (independently of the meaning of the words uttered); a knowledge of these words that present the same appearance to the eye; and sufficient familiarity with the English language to enable the speech-reader to judge by context which word of a homophenous group (like-seeming) is the word intended by the speaker. We should, therefore, teach deaf children to think in English, by using English in their presence in a clearly visible form; teach them to speak, by giving them instruction in the use of their vocal organs; teach them the use of the eye as a substitute for the ear in understanding the utterances of their friends; give them instruction in the ordinary branches of education by means of the English language; and banish the sign-language from our schools.

Bogus American Antiques.—According to the sixteenth report of the Peabody Museum, the manufacture of false American antiquities is becoming an industry of our country. The museum has been offered an "ancient" child carved from stone, duly incrusted with cement, said to have been dug up in Arkansas, the workmanship of which, and the presence of undecayed grass-leaves and yellow printing-paper in the incrustation, showed it to be a near relative of the Cardiff giant. This, however, is only one of many fraudulent specimens that are on sale. Pipes, tubes, dishes, and ceremonial and other objects, are regularly manufactured in Philadelphia, and have found their way into American and foreign collections as genuine antiquities, dug up in such or such a locality. A manufacturer in Indiana gives his attention chiefly to "mound-builders' pipes," which are carved in stone and offered in a systematic manner to collectors. In Ohio a large business has been done in the so-called gorgets, cut from slate, and in hematite celts. In Southern Illinois, a few years ago, specimens of pottery were made till the demand fell off, so that one manufacturer acknowledged that the business no longer paid. On the whole, says Professor Putnam, "the demand for 'antiquities' is considerable in this country, and we are not behind the Old World in keeping up the supply."

The Nettle as an Economical Plant.—The nettle, which is now only rarely cultivated, was held in high honor as a useful plant not more than two hundred years ago. In a medical treatise of the fifteenth century, several pages are occupied with the description of its healing properties. It is said to have been turned to account for food during the Irish famine. In Russia, Sweden, and Holland, it is mowed and made into fodder for cows, with profit in the increase in quantity and improvement in quality of the milk, although the animals will not venture to eat it while it is green. Cords are made from it in Kamchatka, paper in France, and grass-cloth in China and India. It has been made into linen in various countries, a fact of which the German name for muslin, *Nesseltuch* (nettle-cloth), is a standing testimony. When cotton came into general use for textile fabrics the nettle went out, and was nearly forgotten till attention was called to it anew by Professor Reuleaux after our Centennial Exhibition. Frau Rösler-Lade took the matter up and showed how easily the plant could be cultivated and how well adapted it was to spinning. Numerous persons have since engaged in the cultivation of the native species, and of the Chinese nettle, which is considered a little superior, in Germany and other countries. A company has been formed in Holland for the cultivation of the nettle in Java, with a capital of about three million guilders.

Correlations of the Seasons.—The universal mildness of the past winter in Northern Europe has caused attention to be directed to the inquiry whether there is a correlation in character between that and other seasons of the year. Mild winters are by no means rare in that quarter of the world: several may be cited in the last half-century, particularly that of 1842–'43, when the fields around St. Petersburg were bright with flowers in December and violets gathered in the woods were sold in Stockholm in January. Herr G. Hellman has made a special study of the mild winters in Berlin since 1720. He counts thirty-four seasons

since 1755 when December and January were warmer than the mean. The warm seasons come at irregular intervals, and do not suggest any law; seventeen of them came between 1755 and 1821, and seventeen between 1821 and 1884. In seventy-six per cent of these exceptional winters, the month of November also was warmer than usual. Herr Hellman asserts that the chances are eighty-one to nineteen that a warm February will follow a warm December and January, and fifty-seven to forty-three that the same will be the case with March. Thus, the chance is that a winter that begins by putting on a mild face in November will preserve the same aspect all through. In regard to the seasons following these exceptional winters, Herr Hellman finds that a moderately mild winter is more frequently followed by a cold spring, and a very warm winter more usually by a warm spring; and, in general, that the warmer the winter the warmer will be the ensuing spring. These conclusions contradict popular notions.

Physiographic Conditions of Minnesota.—In a lecture on the "Physiographic Conditions of Minnesota Agriculture," recently delivered before the State Horticultural Society, Professor C. W. Hall claimed for that State a nearly central position on the North American Continent, as fixed by lines drawn from Eastport to Astoria, and from Behring Strait to the Isthmus of Panama. Of its area, 83,365 square miles, 78,600 square miles are land, while the rest of the territory is occupied by some 8,000 or 10,000 lakes; 48,000 square miles are forest, and 31,000 prairie. Not quite 40,000 square miles are drained into Hudson Bay, and 7,689 square miles into the St. Lawrence, while the rest of the area of the State sheds its water into the Mississippi. The height of the land ranges from 602 feet above the sea, at Lake Superior, to 2,400 feet in the highest part of the Mesabi, or dividing range between the water-sheds, and averages, for the whole State, perhaps about 1,200 feet. Much of Minnesota is covered by the drift, the various constituents of which—granites and schists, sandstones, clays, and limestones—have been ground up and mingled in utter confusion, so that the land is adapted to the greatest diversity of crops. The average annual rainfall is about 28·27 inches, or about three quarters of an inch less than the average for the whole United States, excluding Alaska. The average January temperature is nearly 12° Fahr., while the July average is nearly 71° Fahr; and the difference between the warmest summer day and the coldest winter night is about 120° Fahr. A reduction in the average temperature is observed of one degree for every 350 feet of additional elevation. As in Nebraska, a gradual increase in rainfall appears to be taking place as more of the prairie-soil is brought under the plow; and the streams are becoming larger, and springs are flowing where once water could not be obtained.

An Absolute Unit of Light.—An absolute standard for the measurement of the intensity of light has long been wanting. All the standards heretofore proposed are imperfect, because in none of them has it been possible to secure complete uniformity in intensity and color. A satisfactory standard should be identical at all times and in all places; should be of convenient size; and should be white enough to be comparable with all modern lights in every region of the spectrum. These conditions appear to be fulfilled in the standard proposed by M. Violle in 1881, which, after some improvement in processes, has been definitely adopted by the International Congress of Electricians. It is the light emitted by a square centimetre of melted platinum at the temperature of solidification (1,775° C., or 3,227° Fahr.). This light nearly resembles the incandescent electric light, and is constant during the whole process of solidification. Its value, expressed in one of the old standards, is 1 carcel = $\frac{1}{9.07}$ of the Violle unit.

Birds' Tastes for Color and Music.—Mr. E. E. Fish has published in the "Bulletin" of the Buffalo Naturalists' Field-Club a paper on "The Intelligence of Birds," in which he ascribes to birds a keen perception of color and capacity to be gratified by artistic arrangements of colors, and a strong susceptibility to musical melodies. Evidence of the enjoyment of color is given by the tasteful combinations with which many birds

adorn their nests, and by instances in which their choice of companions, food-fruits, etc., is guided by color. Many of the feathered tribes also "manifest real pleasure at the execution of simple harmonies. They enjoy the notes of musical instruments, but more especially their own songs and those of one another. . . . Our unmusical English sparrow enjoys the songs of other birds; on different occasions I have seen several of them gather about a robin as he caroled a pleasant song; when they came too near or in too large numbers, he would dart at them and drive them out of the tree, but when he commenced again to sing some of them were quite sure to return. A friend sends me an account of a bobolink, that placed in a cage with some canaries exhibited great delight at their songs. He did not sing himself, but with a peculiar cluck could always set the canaries singing. After a while he began to learn their songs, note by note, and in the course of a few weeks mastered the entire song." The goose is also fond of music, "and a lively air on a violin will sometimes set a whole flock wild with delight. On one occasion, at a country wedding, I was witness of a curious performance by one of these animals. After dinner a lady entertained the guests assembled on the lawn with music from an accordeon. A flock of geese were feeding in the road just below the house, and with outstretched necks answered back loud notes of satisfaction. Soon a white gander commenced dancing a lively jig, keeping good time to the music. For several minutes he kept up the performance, to the great delight of the company. The experiment was tried several times for a week or more, and the tones of the accordeon never failed to set the old gander into a lively dance."

Milne-Edwards's Marine Investigations.—M. Alphonse Milne-Edwards has expressed himself well satisfied with the results of his deep-sea expedition in the Talisman. He claims to have corrected some of the soundings as given in a recent German atlas, and to have traced a different relief from the one indicated in it for the ocean-bed. He found the bottom of the Sargasso Sea—six thousand metres deep—to be of a volcanic character. Some of the lavas and scoriæ in the collection the expedition has brought home seem to be of relatively recent origin, and to offer an explanation of the poverty of the flora of the region in which they were found. In a letter to the French Geographical Society, M. Milne-Edwards speaks of an immense volcanic bed running parallel with the Andes, of which the Cape Verd Islands, the Canaries, and the Azores form the culminating peaks, and which, he conjectures, may extend to Iceland.

The Glacial Dam and Lake of the Ohio River.—Professor G. Frederick Wright, in tracing the boundary-line of the glaciated area through Ohio, found that it crossed over into Kentucky in the neighborhood of Cincinnati, returning, however, to the north side of the Ohio River at a few miles farther down. Examining the ground more closely, he found that the entire valley of the river, for a distance of fifty miles in this region, had been, for a short time during the glacial period, filled with glacial matter which formed a dam at least five hundred and fifty feet high. The effect of this must necessarily have been to make a narrow lake corresponding in depth with the ice-barrier, and extending far up the Ohio and its tributaries, including the Licking in Kentucky, the Kanawha in West Virginia, and the Alleghany and Monongahela in Pennsylvania, and covering the present site of Pittsburg to a depth of about three hundred feet. Evidence of the former existence of such a lake, in the shape of terraces marking its margin, has been found along these rivers, in one case independently of Professor Wright's investigations. Professor J. C. White, of Morgantown, West Virginia, and of the Pennsylvania Geological Survey, says that it is exactly what is needed to explain the terraces along the Monongahela, which extend from Pittsburg as far south at least as Fairmount, West Virginia, one hundred and thirty miles, and "suddenly disappear at an elevation of one thousand and fifty or one thousand and seventy-five feet above tide, or about two hundred and seventy-five feet above the river." Professor Lesley has observed terraces along the Alleghany and its tributaries, at the same absolute level. Along the Great Kanawha, water-worn bowlder deposits disappear at an elevation of from two

hundred to three hundred feet above the present level of the stream. A deserted river-channel, now followed by the Chesapeake and Ohio Railroad, and more than two hundred feet higher than the present river, extends from fifteen miles below Charleston to Huntington, at the mouth of the Guyandotte, through which the Kanawha once flowed to the Ohio. A similar deserted channel, of a similar height, extends from near the mouth of the Big Sandy to Greenupsburg, Kentucky. Mr. G. H. Squier reports evidences of a terrace on the Licking River, near Owingsville, Bath County, Kentucky; and the fact had so impressed him that, before knowing of Professor Wright's discoveries, he had come to the conclusion that some such barrier as is supposed must have existed.

Value of Brain-Weighings. — Recent statements about the weight of Turgenief's brain, which was extraordinarily heavy, have provoked questions as to the value of such data. Mr. Nikiforoff has published an article on the subject. The suggestion is raised that the significance of the weight of the brain is not absolute, but should depend upon the proportion the brain bears to the dimensions of the whole body, and to the weight of the individual. Byron died at the age of thirty-six, and the great geometrician Gauss at seventy-eight years of age. The brains of the two should, therefore not be compared. It is equally important to know what was the cause of death, for protracted disease and old age exhaust the brain. To define the real degree of development of the brain, it is, therefore, necessary to have a knowledge of the condition of the whole body, and, as this is usually lacking, the mere record of weights possesses little significance.

The Boring Power of Mollusks.—Professor F. H. Storer suggests, in a note to Professor Dana, that the shell and rock-boring mollusks owe their excavating power in large part to chemical actions which they induce. Having observed how readily saline compounds are decomposed by way of osmose when put in contact with moistened membranes, and particularly with living membranes, like those in the rootlets of plants, and how plant-roots actually decompose mineral substances, he conceives it probable that mollusks also do their boring by means of chlorhydric acid formed through the decomposition of sea-salt by certain of their tissues. The boring has usually been regarded as a kind of drilling performed by the tooth-like processes attached to the proboscis of the mollusk. Professor Storer does not deny that the teeth may aid in the process of removing the softened shell, but believes that an acid solvent acting upon the shell is primarily operative; and he proposes the question as a fit subject of experimentation.

Sir Bartle Frere.—Sir Henry Bartle Edward Frere, Bart., a distinguished officer in the English colonial service, and a promoter of geographical exploration, died at his home in Wimbledon, England, on the 29th of May. He was born in 1815, and spent his earlier years in the Indian civil service, where he became Governor of Bombay, and member of the Council of India. In 1872 he was deputed on a special mission, connected with the suppression of the slave-trade, to Zanzibar, where he was able to render efficient aid to African exploration. His interest in this work began in 1865, when he helped to raise means to start Livingstone on his last expedition, and gave him an official letter to the Sultan of Zanzibar. At Zanzibar, in 1872, he superintended the departure of Cameron's expedition for the relief of Livingstone. He was an active member of the Royal Geographical Society from 1867, and furnished many papers to it, and was President of the Geographical Section of the British Association in 1869. In 1877 he was appointed Governor of the Cape of Good Hope, and High Commissioner for South Africa. He was prominent in the transactions that led to the war with the Zooloos. He was, says Sir Richard Temple, "a born geographer."

The Fleuss Breathing Apparatus and Safety-Lamp.—The Fleuss apparatus for breathing under water and in irrespirable gases, which was described in Vol. XVI, page 717 (March, 1880), of "The Popular Science Monthly," has acquired a considerable use and has proved efficient in prac-

tice. Mr. Fleuss has also, in conjunction with Mr. Foster, produced a safety mining-lamp which depends for its vitality on principles similar to those of the breathing apparatus, and is equally useful and safe under water and in the most dangerous gases. It is essentially a lime-light, ignited by the burning of methylated spirits instead of hydrogen gas, and securely guarded against contact with the outer air. It will burn for four hours equally well under water, in carbonic acid, or in fire-damp, and it can not get hotter than boiling water. Its usefulness, says "Iron," "we have seen demonstrated by a diver at the Fisheries Exhibition, who, equipped with the breathing apparatus, and having a Fleuss lamp, remained for long periods under water, both man and lamp being wholly cut off from the outer atmosphere during the periods of immersion. In like manner we have seen the respiratory apparatus put to the test by a man equipped with it remaining for some time in an air-tight iron chamber filled with dense smoke and noxious vapors. But above and beyond this is the experience which has been gained from its use in actual practice, notably in the case of the flooding of the Severn Tunnel, as regards subaqueous work, and in the cases of the Seaham and Killingworth collieries with respect to coal-mine accidents." In the case of the explosion at the Lycet collieries, in which several lives were lost, an early exploration, which in ordinary circumstances would have been impossible, was safely effected by means of the Fleuss apparatus.

The Army-Worm.—Several caterpillars have been popularly but inaccurately called the army-worm; but, according to the recently published pamphlet by Professor Riley on the subject, the real worm which is so destructive to growing grass and grain is the *Leucania unipunctata*, a species that has a very wide range on this continent. The worm is the larva of a moth about an inch and a half in wing-expansion, and of a reddish-gray color, which lays its eggs in wild or cultivated grass, or in grain, along the inner base of the terminal blades, where they are yet doubled, or between the stalk and its surrounding sheath, or even in the cut straw of old stacks, or in corn-stalks. The larvæ feed for a time after hatching in the fold of the leaf, which they so resemble in color as usually to escape observation. They are stationary in habit so long as they have sufficient feed, but take up the march when their pasture is exhausted; and in those seasons when they have been multiplied to excess they constitute a veritable army marching in solid rank. Their occasional sudden appearance in vast numbers over large stretches of territory is one of the phenomenal features of their life; but it is not so wonderful a fact, after all. They are nearly always with us in greater or less numbers, and if the season is a dry one they multiply prodigiously. An immense crop of moths is accordingly produced, and then, each one of them laying seven or eight hundred eggs, stock the fields and pastures in profusion, depositing the eggs for the immense host which is to appear in the following year. In confirmation of this view, examinations of the weather records show that the years preceding army-worm years have been universally characterized by drought. Three broods of them may be produced in a year. Their natural enemies are not less than fourteen species of birds, a metapodious bug, and numerous parasites. The usually applied remedies look to the wholesale destruction of the worms or the eggs. Among them are burning the old grass, preferably as late as possible in the spring; digging a ditch to serve as a trap into which they will fall on their march, after which they may be destroyed in various ways—mashing them in the field with heavy rollers, and dragging a rope across the field to crush them. Thin tillage is also a preventive, by causing the worms to be exposed to the sun.

What destroyed Casamicciola?—Professor Palmieri, of the Mount Vesuvius Observatory, believes that the destruction of Casamicciola, in Ischia, was not the immediate effect of the earthquake, but was caused by a caving in of the ground under the city, which might, perhaps, have been precipitated by an earthquake-shock. The trachytic rocks on which the town is built rest upon a bed of clay, in which extensive galleries have been dug in the course of centuries, while the clay has been mined for industrial purposes. As early as 1837,

an engineer, Alessandro Giordano, called attention to the danger of extending these excavations farther toward the city. Add to this the action of the carbonic waters of the thermal springs in hollowing out caverns in the trachytic rocks, and we have probable a condition of the subsoil and underlying formations extremely perilous to the stability of the foundations of the town, and one under which just such a disaster as has overtaken it might be readily conceivable.

M. WROBLEWSKI has been investigating the boiling-points of air, oxygen, nitrogen, and carbonic oxide, at the ordinary pressure of the atmosphere, and fixes them as follows: Oxygen, 299° Fahr.; atmospheric air, 314°; nitrogen, 315·5°; carbonic oxide, 314·4°. Atmospheric air seems destined to be the refrigerant of the future, for it is already at hand, and will produce a degree of cold that is only insignificantly exceeded by that induced by any other substance. It must, of course, be first compressed and liquefied; then, when it is to be used, it will be let loose to freeze by its evaporation, as is now done with other refrigerants operating in a similar way.

M. GUSTAVE HERMITE describes a method of taking phosphorescent photographs, which he has found to be practicable with any phosphorescent substance, but for which he prefers sulphuret of calcium, a material from which a luminous paint is made. This substance is very sensitive to light, and assumes a phosphorescence the intensity of which is proportioned to the intensity of the light to which it is exposed, rather than to the length of the exposure. A glass plate is painted with it, and is exposed in a bright light in the face of the object of which a picture is desired. The picture appears very distinct when the plate is taken into the dark. It may be revived afterward by breathing upon the plate, and then passing a hot flat-iron over it. Sulphuret of calcium becomes phosphorescent under the influence of heat (300° C.) as well as of light.

M. E. L. TROUVELOT has concluded, from observations on the planet Saturn for several years, that his rings are not fixed but very variable; and that the hypothesis that they are composed of multitudes of corpuscles or minute satellites, revolving in independent orbits, is very probable, and affords the best explanation of the phenomena.

NOTES.

DR. AUSTIN FLINT is quoted in the seventeenth report of the Peabody Museum as authority for the statement that the *metates*, or grinding-stones, used in Nicaragua, are obtained from the old burial-mounds. Dr. Flint informs us that this is true, so far as the northwestern departments of Costa Rica are concerned, but that the idea of the same being the case in Nicaragua is an error, arising from an inaccuracy of his own expression incidentally committed in writing hurriedly on another subject. The *metates* in universal use in Nicaragua are made there now, and are much inferior to those found in the mounds; and, being of much less value, they are gradually being bought in Costa Rica.

THE biological class at the University of Cambridge has outgrown the capacity of any lecture-room to accommodate it, and at the last term numbered two hundred in the elementary department alone. A considerable number of graduates remain at the university engaged in biological research, and the museums are continually being enriched with specimens presented by recent graduates who are traveling on scientific expeditions.

GENERAL SIR EDWARD SABINE, for ten years President of the Royal Society, and for twenty years General Secretary of the British Association, recently died at Richmond, England, aged ninety-four years. After serving on the English side in the war which we call the War of 1812, he became officially engaged in scientific work, and served his government and the scientific associations for twenty years in astronomical and magnetic investigations, in the course of which he was connected with several Arctic and marine expeditions. He was elected General Secretary of the British Association in 1839, Foreign Secretary of the Royal Society in 1846, and Vice-President and Treasurer of the same in 1850; and was President of the Royal Society from 1861 to 1871. Our present conception of the exact figure of the earth is said to be mainly due to his investigations. A portrait and sketch of General Sabine were published in the second number of Vol. II of "The Popular Science Monthly."

M. PASTEUR, in consideration of his researches in hydrophobia, has been awarded a gold medal by the French *Société Centrale pour l'Amélioration des Races des Chiens.*

THE London Sanitary Protective Association, at the close of its second year, had five hundred and thirty-three members. During the year it had secured the inspection of three hundred and sixty-two houses, with the discovery and correction of many serious errors in sanitary arrangements. Six per cent of these houses had their drains choked up so that the foul water from the sinks simply soaked into the ground; in thirty-two per cent of them the soil-pipes were leaking, and sewer-gas could escape into the house; in thirty-seven per cent the overflow-pipes from cisterns passed direct into the drains or soil-pipes, admitting sewer-gas into the water of the cistern and into the house; and in three fourths of the houses waste-pipes from baths and sinks led direct into the drainor soil pipes instead of, as they should, direct into the open air. Professor Huxley resigned the presidency of this society, and was succeeded by the Duke of Argyll.

MR. HAROLD PALMER, an English health inspector, has reported an infectious form of pneumonia in his district. A man was attacked with symptoms suggesting that septic poison and bad sanitary conditions might be around, and examination confirmed the opinion. Three other persons were seized with the disease, and two of the patients, including the medical attendant, died. Other similar cases have been observed, in one of which inflammation of the lungs and death followed a single visit to a house where the disease was prevailing.

DR. A. J. C. GEERTS, Professor of Natural Sciences, etc., in Japan, died recently at Yokohama, aged forty years. He was invited by the Japanese Government, in 1868, from a professorship at Utrecht, to fill a similar position in the new medical school at Nagasaki. He afterward became a member of the health department at Tokio, and established chemical laboratories at Kioto and Yokohama. He contributed to the two learned societies of Japan, published a Japanese pharmacopœia, and began a colossal work on the "Products of Nature in Japan and China."

RAILROAD-CARS are indicated by Judge Lawrence Johnson, of Holly Springs, Mississippi, as vehicles by which destructive moths are carried from one part of the country to another. In traveling last year he was often struck by the numbers of *Aletiæ* on the trains; and he observes that there was a sort of coincidence last season between lines of railroad and abundance of cotton-worms.

MR. W. A. FORBES, Prosector of the London Zoölogical Society, died on an expedition up the Niger, January 11th, of dysentery at less than thirty years of age. He was a well-known writer on zoölogical subjects. He contributed a memoir on the petrels to the reports of the Challenger Expedition, and edited the collected papers of Professor Garrod, his predecessor as prosector.

THE Board of Trustees of Johns Hopkins University announce, as a special feature of the university course of instruction in physics for 1884–'85, a series of eighteen lectures, to be delivered by Sir William Thomson, in October, on "Molecular Dynamics." The programme also includes lectures by Professor Rowland, on "Electricity and Magnetism"; by Associate Professor Craig, on "Analytic Mechanics," "Hydrodynamics," and "Partial Differential Equations"; and by Dr. Franklin, on "Problems in Mechanics," with general lectures by Dr. Kimball.

HENRY WATTS, F. R. S., editor of the "Dictionary of Chemistry," died of syncope, from failure of the heart's action, June 30th, in the seventieth year of his age. He was graduated Bachelor of Arts in the University of London in 1841, and was Demonstrator of Anatomy in University College, London, under Professors Fownes and Williamson, from 1846 to 1857. He translated and supplemented Gmelin's "Handbook of Chemistry," composing a work of eighteen volumes. Having begun a new edition of Ure's "Dictionary of Chemistry and Mineralogy" in 1858, he soon found that, to bring it up with the times, the book would have to be rewritten. Calling in the aid of other students, he produced his great work in five volumes, in 1868. Three supplements were added to it, in 1872, 1875, and 1879–'81. He also brought out three editions of Fownes's "Manual of Chemistry," and had a fourth ready.

ALPHONSE LAVALLÉE, a distinguished French student of trees, and writer upon them, died at his home in Segrez, on the 3d of May, in the fiftieth year of his age. His collection of trees and shrubs is the richest and most complete *arboretum* ever established. In preparing the catalogue of it some years ago, he introduced considerable reforms in nomenclature and synonymy, which he elaborated in the second edition of the work. Among his works was the "Arboretum Segrezianum," intended to furnish descriptions of the rarest plants of his collections, richly illustrated with steel-plate engravings, and an illustrated folio on large-flowered clematises. He was about to publish a similar work on *Crataegus*, or the thorn. He was President of the Central Horticultural Society of France.

M. E. BERGMAN has observed that formic and acetic acid occur in the protoplasm of all the plants he examined for them, being found in the colorless cells and in the green tissues; and he considers it probable that several other acids of the fatty series are equally diffused in the vegetable kingdom.

LORD RAYLEIGH.